Japanese Albacore and Bigeye Tuna Size Composition Studies

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JAPANESE ALBACORE AND BIGEYE TUNA SIZE COMPOSITION STUDIES

Translated from the Japanese language by

W. G. Van Campen, Translator
Pacific Oceanic Fishery Investigations
U. S. Fish and Wildlife Service
Honolulu, T. H.

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Size Composition of Albacore and Bigeye Tuna of the North Pacific Fishing Grounds*

By

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Nankai Regional Fisheries Research Laboratory

[English title and summary]

Size Composition of the Albacore and Big-eyed Tuna Caught in the North Pacific Area

1) The data upon which this report is based have been obtained during the two periods, viz., Nov. '48-March '49, and Oct. '49-March '50. The fishes measured were taken exclusively by the longline. The length given in this paper is the so-called fork length. The North Pacific Area, in this paper, is the seas north of 26°N., between 130°E.-770°W.

2) As shown in fig. 1, the most dominating size of the albacore is from 60 cm. to 110 cm. in length; the min. is 41 cm. and the max. is 119 cm. in both periods, while the dominating size of the fish taken by rod and line is between 70 cm. and 90 cm., as shown in fig. 2 (after Uno).

Such large-sized ones as those taken by long-line are more variable in length than those taken by rod and line. The difference in size composition of both catches is thought to be due to the difference in the fishing methods, seasons and grounds.

3) It is recognized clearly that there is a remarkable difference in the size composition of both periods, namely, the mode C in the former period is perfectly in discord with the mode B and D of the latter period; and the mode E and F, which appear clearly in the former period, are quite indistinct in the latter.

4) We explain the phenomenon mentioned above as follows:

a) The difference in length is caused by the annual difference of the growth.

If it is assumed that the fishes migrating in a certain sea in a certain season are always composed of the definite age groups, then the mode A and C are composed of the X-age and (X + 1)-age group respectively. On this supposition, the fish forming the mode B must be the remarkably well-grown group of the X-age, or the quite undergrown group of the (X + 1)-age. It is known in some cases of the fresh water fishes that their annual growth is greatly affected by the environmental conditions. If this holds true with such pelagic fish as albacore, it may be said to be an interesting phenomenon.

b) The difference in length is caused by the difference in the annual propagation.

On this supposition, modes A, B, C, ····· F are thought to be formed by the X, (X + 1), (X + 2), ····· (X + 5)-age group respectively. The reason why the modes are, or are not, formed for respective years, may be considered to be due to the difference in the propagation from year to year.

c) The difference in length is caused in the difference of the course of the migration.

(Contribution No. 12 of the Nankai Regional Fisheries Research Laboratory, published in 1953 in Contributions of Nankai Regional Fisheries Research Laboratory, No. 1.

Translator's note: The literature citations for the six papers in this collection have been combined and amplified and will be found at the end of this report.

This supposition means that the course of the migration differs annually, even in the case of the definite age group, and they do, or do not, migrate to the North Pacific Area.

5) If these sizes corresponding to the modes indicate the age groups respectively, there is a close relation between the present data and the growth-rate given by Aikawa and Kato.

6) Fig. 3 shows that the tendency of the variation of the curves of the length composition of the big-eyed tuna is quite similar to that of the albacore. Therefore, the hypotheses mentioned above are considered to be equally established as tenable for the big-eyed tuna.

7) These phenomena may be explained in more detail by further research, but it is thought to be sure that the phenomena will contain many important problems relevant to ecology or studies of the stocks of these fishes.

/end of English summary/

The size composition of pole-and-line-caught albacore landed at the Misaki Fish Market has already been reported upon by Uno (1936a, b), but nothing has been reported on the longline catch. The present paper is a report of measurements by the authors of albacore and bigeye tuna taken on longlines in the North Pacific fishing grounds in the autumn and winter.

1. Materials

The data were collected in two periods, the first from November 1948 to March 1949 and the second from October 1949 to March 1950. The numbers of vessels covered and the numbers of fish measured by months are shown in table 1.

When the operations of a vessel have extended into two months, they have been classified under the month in which the majority of the fish were taken, as based on their reports of their fishing. The measurement taken was the so-called fork length, and the measurements were grouped by classes of 2 cm. in the case of the albacore and 4 cm. for bigeye. No definite rule was set up for the selection of vessels or of fish, but as many measurements were made as conditions permitted. The North Pacific fishing grounds referred to in this paper include the area north of 26°N. latitude between 130°E. and 170°W. longitude.

2. Size composition by species

A. Albacore, Thunnus germo (Lacépède)

In figure 1 the size compositions for the two periods referred to above, November 1948 to March 1949, and October 1949 to March 1950, are shown as percentages. As is clear from the figure, the size ranges in the landings are in very good agreement, both groups being principally composed of fish from 60 to 110 cm. in length. To

Table 1.--Number of ships and fish sampled by month

Year	Month	T. germo		P. mebachi	
		Ships	Fish	Ships	Fish
1948	11	5	131	-	-
	12	22	2,055	39	1,492
1949	1	26	10,454	29	1,337
	2	13	3,136	3	88
	3	6	2,454	7	462
Total		72	18,230	78	3,379
1949	10	14	1,673	16	1,170
	11	17	2,407	12	881
	12	21	3,204	21	1,151
1950	1	35	7,551	20	716
	2	23	4,190	19	610
	3	13	2,102	10	446
Total		123	21,127	98	4,974

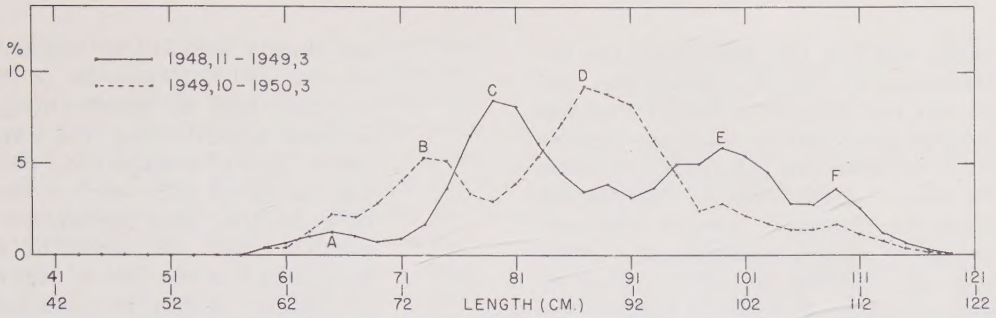

Figure 1.--Length composition of the albacore.

show the makeup of the smallest and largest size groups, in 1948-49 and 1949-50 the smallest class at 41 cm. included one fish in each of the two periods, the largest class of 119 cm. comprised two and four fish respectively. Kishinouye (1923) states that for this species, fish of 25 kg. are considered large, and in Japanese and Hawaiian waters fish of 45 kg. probably represent the maximum size. The aforementioned specimens 119 cm. in length are estimated to be about 35 kg. in weight and thus are not of the size which Kishinouye presumed to be the maximum.

Figure 2 shows the size composition of pole-and-line-caught albacore examined in the Misaki Fish Market by Uno (1936a) in May and June of 1935.

The composition is shown by the actual numbers of fish at 1 cm. intervals. If this is compared with the size composition of longline-caught fish in figure 1, a marked difference between the two can be detected. Whereas in figure 1 the aforementioned 60 to 110 cm. group is predominant, in figure 2 the fish between 70 and 90 cm. predominate. That is, the former is made up of a broad range of small, medium, and large sizes, whereas the latter is made up of medium and small fish and includes hardly any large ones. The causes of this difference can be thought to be (a) the difference in fishing method and (b) differences in fishing season and fishing ground. In the case of (a) little can be said because there are no data with which to make a direct comparison, but concerning (b) the following points of difference can be adduced. In longlining the fishing season is from October to March and the fishing grounds extend from waters adjacent to Honshū out to 170°W. longitude. On the other hand, the fish measured by Uno were taken during the season of May and June and within a range of about 250 miles at most from the coast of Honshū. Uda and Tokunaga (1937) have discussed the relationship between albacore fishing conditions and oceanographic conditions in this

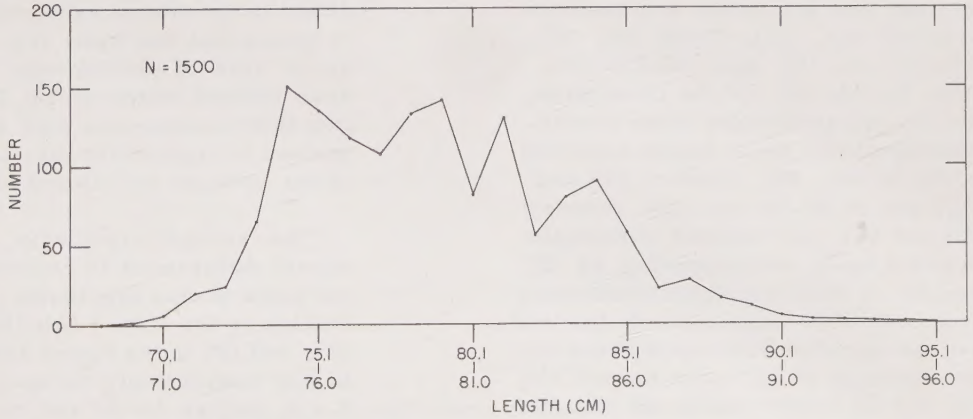

Figure 2.--Length composition of the albacore (after Uno 1936a).

area, and Uda has postulated the existence of an inshore population and an offshore population and further has hypothesized that the offshore population includes two migratory strains. He also reported that as one moves from the coastal waters offshore groups of small, medium, and large fish are found in that order, each of them forming a separate migratory population, and that these groups mingle in the vicinity of 40°N., 165°E. If we follow these hypotheses of Uda, the catch of the longline fishery clearly includes fish from both the inshore and offshore groups, while the catch of the pole-and-line fishery can be thought to be made up principally of fish from the inshore population. Consequently, if we think of the difference in size composition seen in figures 1 and 2 as a difference in the size composition of the inshore and offshore populations, we can consider this to tend to agree with the hypothesis of Uda and Tokunaga. However, there is still room left for examination of the question of whether or not this sort of difference in the size composition is due to a population difference. In investigating problems of this sort it will be extremely important to analyze the makeup of the fishing grounds and the seasonal and regional changes in size composition, but these are questions which must be left to the future.

When we attempt, using figure 1, to compare the size composition for the two periods 1948-49 and 1949-50, we can see a marked difference between the two. For 1948-49 it can be seen that the modes are centered at 65-66 cm. (A), 79-80 cm. (C), 99-100 cm. (E), and 109-110 cm. (F). In 1949-50, on the other hand, we can see an obscure mode corresponding to (A), clear modes centered at 73-74 cm. (B), between (A) and (C), and at 87-88 cm. (D), between (C) and (E), and another extremely obscure mode corresponding to (E) and (F). In other words, the outstanding apparent differences between the two are the complete discrepancy between the positions of (C) in the former and (B) and (D) in the latter and the fact that (E) and (F), which were clearly apparent in the former, have become extremely obscure in the latter. As causes for differences of this sort we can think of shortcomings in the method of collecting the data and of basic natural phenomena. Since there was no great difference in the method of collecting data throughout the two periods, this can hardly be thought to be a cause of the above described discrepancy. If they are considered to be based on natural phenomena, then the following three hypotheses can be advanced.

The first hypothesis is that of annual differences in growth. We will assume that a certain age group migrates into the same area at the same season. Modes (E) and (F) are certainly obscure but since they do appear in both years there is no problem. Now if we assume that the groups making up modes (A), (C), and (E) are respectively X age, X + 1 age, and X + 2 age, the group making up mode (B) can be thought of either as fish of X age which have grown remarkably well in comparison with those of the previous year or as fish of X + 1 age which have grown remarkably poorly. In the same manner the group making up mode (D) must be thought of as either well grown fish of X + 1 age or as poorly grown fish of X + 2 age.

In fishes of ponds and lakes, marked differences in growth from year to year because of environmental factors and because of the amount of reproduction of the fish can be seen, and it is known that in the case of the pond smelt there is good growth and bad growth in alternate years. Assuming that we can detect in the albacore distributed broadly throughout the open sea exactly the same sort of phenomenon we find in such limited water areas, it is thought that this phenomenon may give an important indication for the investigation of the ecology and stocks of this fish.

The second hypothesis is that of annual differences in recruitment. On the basis of this hypothesis, the groups making up the modes (A), (B), (C), (D), (E), and (F) in the figure are thought to belong respectively to ages X, X + 1, X + 2, and so forth, and the fact that fish of the same age group may form a mode in one year and not form one in

another is explained as being based on the fact that recruitment fluctuates markedly from year to year. Starting out from this line of thought, it is possible to consider in the case of modes (B), (C), (D), and (E) that from the remarkable differences apparent between the two periods it is to be assumed that the alternation of a year of successful reproduction and a year of unsuccessful reproduction was continued through two cycles. Furthermore, if we consider the modes (A), (B), (C), (D), (E), and (F) each as a separate age group and get their growth rate, we come out in approximate agreement with the estimates of Aikawa and Kato (1938). If this second hypothesis is to stand, we must in the future place the emphasis in our studies of the stocks on finding the period of cyclical changes in reproduction and in investigating their causes. Furthermore, length measurements of the catch may provide a direct clue to finding the growth rate.

The third hypothesis is that there is no great difference in recruitment from year to year, but that the year groups X, X + 1, X + 2, and so forth change their pattern of migration markedly from year to year, sometimes appearing in the North Pacific fishing grounds and sometimes not. However, there is no way of getting evidence to support this theory without carrying on investigations over a wider area of the ocean. It cannot be said at present whether the sudden decline of the large fish above the group making up mode (F) is due to natural attrition or to their making a complete change in their range of occurrence and moving from this sea area into another.

B. Bigeye Tuna, Parathunnus mebachi (Kishinouye)

Figure 3 shows phenomena very similar to those seen in the case of the albacore. For the period from November 1948 to March 1949 the composition shows clear modes centered at 85-88 cm., 121-124 cm., and 149-152 cm. Another obscure mode can be seen centered at 73-76 cm. In contrast to this, in the period from October 1949 to March 1950 the composition shows highly predominant modes centered at 93-96 cm. and 137-140 cm., with an obscure mode centered at 105-108 cm. The size compositions in the two periods show marked discrepancies in the position at which the modes appear and the form in which they appear. Accordingly, as causes for this sort of difference, we can consider the establishment of exactly the same sort of hypotheses that were brought forward in the case of the albacore.

At the present time we do not know whether the above-described phenomena, which are shared by the albacore and the bigeye, are due to any one of the three hypotheses just set forth, or to some completely different reason, or to a complex mixture of these. We believe that these questions will be gradually clarified in the future, and assume that they will have an extremely important significance for the investigation of tuna resources.

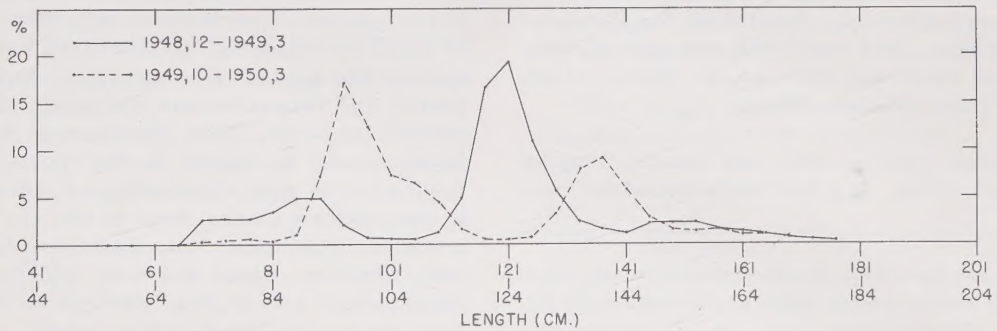

Figure 3.--Length composition of the bigeye tuna.

Albacore Studies. I. Size Composition of Albacore Taken in the North Pacific During the Period of Southward Movement*

By

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/English title and summary/

Studies on the Albacore - I. Size Composition in the North Pacific Ground Between the Period of its Southward Migration

The distribution of the Albacore in the North Western Pacific extends from the Equator area to near the Polar Front Area However the fish distributes in such vast area, the fishing grounds are limited almost in the seas between the Subtropical Convergence and the Polar Front, namely in the waters of the North Pacific Current and the north part of the Kuroshio Current.

This fish is caught mainly by the rod and line with live baits in the season between the Spring and Summer, but it is caught mainly by the long-line in the season between the late Autumn and the early Spring. The fishing grounds in the former season moves from south to north, and on the contrary, the grounds moves southward from nearly 40°N. to as far as 27°-28°N. in the latter, and then seem to turn back.

The present author attempted the analysis of the size composition of the fishes which are caught in the latter season, and obtained the result as following.

1) Six different size groups appear in every year. When these six groups are hypothesized to correspond to each other in every year, the modal lengths of the five seasons between 1948 and 1952 are placed with nearly the same intervals as ca. 57cm, 67cm, 78cm, 89cm, 100cm, 110cm.

2) Two groups with the modal lengths 78cm and 98cm, are far more abundant than the others. So far the data obtained, it is clearly recognized that these two dominant groups appear alternately in every other, namely group with the modal length of 78cm are most abundant in the even number years and the other in the uneven number years.

/end of English summary/

Introduction

The distribution of albacore in the northwest Pacific extends over broad areas from the Equator to the Polar Front. However, mass occurrences are limited to the north side of the Subtropical Convergence, a part of the Kuroshio, and the area of the North Pacific Current. In recent years there has been a gradual increase in the landings of albacore in Japan from the southern hemisphere, but the greater part of the landings still come from these areas. The albacore fishing in these areas can be divided into two fishing seasons of different character. One is the pole-and-line fishing season for schools moving north from April to July, and the other is the longline fishing season for southward moving schools from November to April.

With regard to the size composition of the pole-and-line-caught albacore, we already have the reports of Uno (1936a, b). For the size composition of the longline-caught albacore there is the report of Nakamura, Yabuta, and Kamimura (1953), and the aim of the present paper is to take up where they left off and attempt to analyze the albacore size composition of longline catches from the above-mentioned sea areas over the 5-year period from 1948 to 1952. Consequently, pole-and-line-caught fish are completely excluded. From November on, the albacore longline fishing grounds move south from month to month. In March their southern margins reach 27°-28°N., the southward movement stops, and there is a transition to the period of northward migration. In order to limit the material summarized here to albacore of the southward migration, fish taken in March and thereafter are excluded. During this period, at least, little change can be detected from month to month in the positions of the modes in the size composition. Albacore taken in the waters to the west of the Izu and Ogasawara archipelagos have been excluded, and only albacore taken between 140°E. and 180° on the north side of the Subtropical Convergence have been considered in this study.

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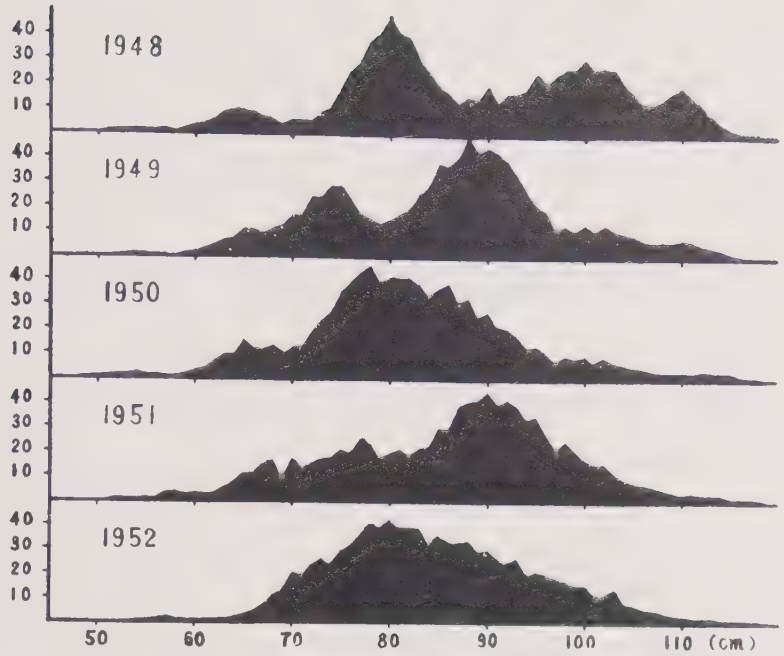

Figure 1. --Length frequency of the albacore caught in the northwestern Pacific during the longline season (indicated by permillage).

The data were gathered by the Nankai Regional Fisheries Research Laboratory[1/] by working on fish landed at markets during the period. From 1948 to 1951 measurements were taken of as many fish as possible from the maximum possible number of boats; in 1952 measurements were taken on a sampling ratio of 0.1 of the fish from 0.5 of the voyages.

Before entering upon the text of the paper, the author wishes to express his gratitude to Director Nakamura and Mr. Yabe for their assistance, to the various personnel of the High Seas Resources Section who collected the data, and to Miss Michiko Momota, who processed the data.

1/ Measurements taken during this period were as follows:

Year	Location	Number of trips sampled	Number of fish measured
1948	Tokyo	66	15,801
1949	"	106	18,516
1950	"	88	15,131
1951	"	58	16,777
1952	Tokyo, Yaizu	214	40,489

Body Lengths of the Schools of Albacore Migrating Southward in the North Pacific

Figure 1 shows by years from 1948[2/] to 1952 the length composition in permillages of albacore landed from this area. The length used is the fork length. The length range of albacore taken by longlines in these fishing grounds is very broad, extending from about 50 cm. to 120 cm. In the measurements taken over a period of 5 years the smallest specimen was 37 cm. and the largest 121 cm. in length. Fish longer than 120 cm. were extremely rare and in 5 years only 5 were encountered.

The length distribution curve is extremely complex, with either several modes appearing

2/ The albacore longline fishing season extends each year from November to March of the following year (this report covers to February). The "year 1948" as used in this report means from November 1948 to March (for the purposes of this report to February) of 1949, and so on for the other years.

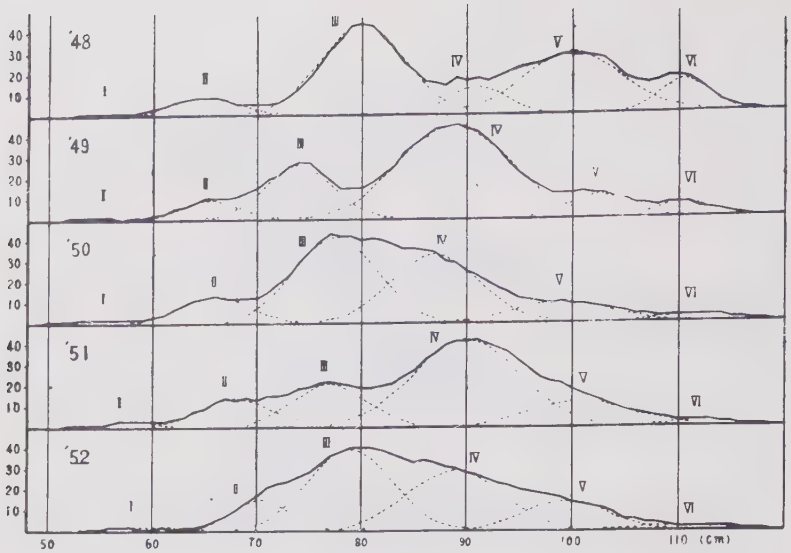

Figure 2.--Length frequency of the albacore caught in the northwestern Pacific during the longline season (indicated by permillage). Solid line - length frequency curve indicated by lapped mean between three length classes. Broken line - length groups estimated by fitting normal curves.

at the same time or appearing to fuse together. Consequently, this is interpreted as the appearance at the same time of a number of different size groups. In figure 2 the solid line shows in permillages the results of smoothing the actual measured values with a moving average of 3 cm. The dotted lines are the result of an attempt to analyze this into a number of normal distributions.[3/] According to this, for each year we can detect six size groups. In view of the fact that there is general correspondence among the positions of each size group, we set up the assumption that "six size groups which correspond from year to year appear in the albacore captured in the North Pacific. Some degree of variation in their modal length from year to year can be seen." On the basis of this assumption we shall try to bring out some of the characteristics of these size groups.

Results - I. Positional Relationships of Each Size Group

Table 1 shows the modal lengths for each age group, the groups having been designated as I to VI from the smallest fish to the largest. Tables 2 and 3 show respectively the direct difference of the modal length[4/] and the lagged difference[5/]. The following statements can be made on the basis of tables 1 to 3:

1. The average modal lengths of each group for the 5 years from 1948 to 1952 are approximately 57 cm. for group I, 67 cm. for group II, 78 cm. for group III, 89 cm. for group IV, 100 cm. for group V, and 111 cm. for group VI.

[3/] Normal distributions with various average sizes, standard deviations, and total numbers have been set up, and those whose sums best fit the results of the treatment with a moving average have been taken up. The goodness of the fit for each year has been examined by the chi-square test. With the length classes 2 centimeters, and decreasing the degrees of freedom each year (3 X 6 + 1), each case gave a fit of $P > 0.9$. (1 degree of freedom for each determination of the number of normal distributions, and since 6 normal distributions were fitted each year and for each of them 3 parameters were determined, the degrees of freedom were decreased by 18 or a total of 19.)

[4/] Difference in modal length for group N and group N + 1 in the same year.

[5/] Difference in modal length between group N for a given year and group N + 1 of the following year.

Table 1.--Modal length of each length group

Year	Group No.					
	I	II	III	IV	V	VI
1948	56.5	65.0	80.0	91.0	100.0	110.5 cm
1949	54.0	65.5	74.0	88.8	102.5	110.5
1950	55.0	66.0	77.5	87.0	99.0	112.0
1951	58.0	68.0	77.0	90.0	100.6	112.5
1952	59.0	70.5	79.0	89.0	99.5	110.5
$M \pm \sigma$	56.5 ± 1.56	67.0 ± 2.02	77.5 ± 2.05	89.2 ± 1.33	100.3 ± 1.21	111.2 ± 0.87

Table 2.--Direct difference between successive length groups

Year	Group No.				
	II - I	III - II	IV - III	V - IV	VI - V
1948	8.5	15.0	9.0	9.0	10.5 cm
1949	11.5	8.5	14.8	13.7	8.0
1950	11.0	11.5	9.5	12.0	13.0
1951	10.0	9.0	13.0	10.6	11.9
1952	11.5	8.5	10.0	10.5	11.0
$M \pm \sigma$	10.50 ± 1.14	10.50 ± 2.51	11.26 ± 2.25	11.10 ± 1.59	10.80 ± 1.74

Table 3.--Lagged difference between successive length groups

Year	Group No.				
	II - I n+1 n	III - II n+1 n	IV - III n+1 n	V - IV n+1 n	VI - V n+1 n
1948 (n)-49 (n+1)	9.0	9.0	8.8	11.5	10.5 cm
1949 (n)-50 (n+1)	12.0	12.0	13.0	10.2	10.5
1950 (n)-51 (n+1)	13.0	11.0	12.5	13.6	13.5
1951 (n)-52 (n+1)	12.5	11.0	12.0	9.5	9.9
$M \pm \sigma$	11.63 ± 1.56	10.75 ± 1.09	11.56 ± 1.64	11.20 ± 1.56	11.10 ± 1.41

2. No conspicuous difference can be seen between the 5-year average values for the two differences and the standard deviation.

3. The intervals for each group for both the direct difference and the lagged difference are 10.5 cm. to 11.5 cm., and the several size groups are spaced at intervals of a little more than 10 cm. The intervals are approximately the same for each size group regardless of whether it consists of large or small fish.

The ranges of body length in each group are as shown in table 4a, b, and c. The breadth of distribution of all groups is rather large, and the two extremes overlap with the adjoining groups. For groups III to V the breadth of the distribution is far greater than the interval between modal lengths, being more than 20 cm. in most cases. However, there is hardly any overlapping between the length ranges which include 80 percent of each group. The average values from 1948 to 1952 of the boundaries of the ranges within which the various length groups are dominant are as follows: groups I-II, 59.8 cm.; groups II-III, 70.7 cm.; groups III-IV, 83.3 cm.; groups IV-V, 96.3 cm.; groups V-VI, 107.7 cm.

Table 4.--Some characteristics of the ranges of the six length groups

a. Extreme ranges of each group

Year	Group No.					
	I	II	III	IV	V	VI
1948	53-60	58-72	69-91	85- 97	88-112	105-116
1949	52-56	59-72	65-83	74-104	96-109	105-116
1950	51-59	58-74	67-88	74- 98	89-109	106-118
1951	54-62	60-76	69-85	77-103	91-111	107-118
1952	53-65	64-77	68-90	78-100	90-109	103-118

b. Range in which each group is dominant

Year	Group No.					
	I	II	III	IV	V	VI
1948	< 58.5	58.5-70.0	70.0-88.0	88.0-93.0	93.0-107.5	107.5 <
1949	< 57.5	57.5-68.0	68.0-79.0	79.0-99.5	99.5-107.0	107.0 <
1950	< 58.5	58.5-70.0	70.0-83.5	83.5-94.5	94.5-107.0	107.0 <
1951	< 60.5	60.5-72.0	72.0-81.5	81.5-98.5	98.5-110.0	110.0 <
1952	< 64.0	64.0-73.5	73.5-84.5	84.5-96.0	96.0-107.0	107.0 <

c. Range of $m \pm 1.28\sigma$ of each group (in this range 80 percent of the individuals of each group are contained)

Year	Group No.					
	I	II	III	IV	V	VI
1948	53.5-59.5	61.0-69.0	75.0-85.0	87.5-94.5	94.0-106.0	109.0-110.5
1949	53.0-55.0	63.0-68.0	71.0-77.0	83.5-94.0	100.0-105.0	108.5-112.5
1950	53.0-57.0	63.0-69.0	73.5-81.5	83.0-91.0	94.5-103.5	109.0-115.0
1951	56.0-60.0	65.0-71.0	74.0-80.0	85.0-95.0	96.0-105.0	110.0-115.0
1952	54.0-64.0	67.0-74.0	74.0-84.0	83.0-95.0	94.5-104.5	104.0-117.0

Results - II. Quantitative Relationships Among the Length Groups

With regard to the quantitative occurrence of each length group, the two central groups of the six, that is group III and group IV, are most outstanding. These two groups form a peak with the occurrences declining as one goes toward both ends of the distribution. The permillage of each group is shown in table 5. For every year, group III and group IV make up more than half. On the average, for the 5-year period group III and group IV together predominate overwhelmingly, forming 70 percent of the whole.

Table 5.--Relative abundance of the six length groups (by permillage)

Year	Group No.					
	I	II	III	IV	V	VI
1948	8	64	429	85	329	86
1949	5	65	214	593	77	46
1950	14	106	405	339	109	27
1951	17	118	180	527	139	20
1952	20	102	401	318	136	24
M	13.8	91.0	325.8	372.4	158.0	40.6

When we look at the proportion occupied by each size group from year to year, we see various different trends. For example, the relative proportion of groups I and II increases

pm year to year. Group VI on the other nd decreases. Groups III and IV and also do not show any clear tendency to increase decrease. Consequently we can see that of six size groups which appear in this fish- ground the three near the middle do not esent any clear tendency to increase or de- ease but the smaller size groups show a lative increase while the groups of larger e fish show a relative decrease.

Of the three size groups nearest the ddle, in group III and group IV another con- cuous annual change can be seen. This is alternate year cycle appearing in the quan- of occurrence of these two groups. Group occurs conspicuously in even-numbered ars and is scarce in odd-numbered years. oup IV appears in small numbers in even- mbered years and is outstanding in odd- mbered years. Consequently they alternate ery year in predominance.

Discussion of the Results

Basically, in analyzing the size composi- n into a number of groups with different aracteristics, we should take as a standard characters which they actually possess. we take as a basis only the form of the size tribution and thus separate them, it is ught that some degree of subjectivity and or will be introduced. Therefore the va- ty of the size groups separated by this thod should be examined by comparing for h character the results of the direct analy- of the size composition with actual phe- ena. However, at the present stage we do have data which would enable us to make h an examination for each character, and thermore it is thought that of the various sible/ characters there is the greatest ibility that the groups are based on age. nsequently in what follows we shall try to examine one or two points in terms of age groups.6/

a. In Japan, Uno (1936a, b) and Aikawa (1937) and Aikawa and Katō (1938) have studied the age of albacore by means of the vertebrae. The following is the comparison of their results with the spacing of the modal lengths.

a1 Comparison with the results of Aikawa and Katō:

The absolute values of the differences can not be said to be large. A considerable difference in the trend can be seen. According to Aikawa and Katō's results, the interval between each age group and the next, with the exception of that between age group I and age group II, is 9 cm. Consequently, the five intervals between age groups I to VI are all about 2 cm. larger than the values shown by Aikawa and Katō.

Aikawa and Katō did not separate the size composition directly by the number of rings in the vertebrae, but they used the indirect method of finding

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6/ Differences in size of the fish depending on sex do not appear to participate in the formation of the size groups. Figure 3 shows the results of an examination of the sizes of fish by sex carried out on a research vessel in March 1953. It is unavoidably somewhat rough because it was not possible to carry out an investigation of age at the same time, but at any rate between 70 cm. and 100 cm. no marked difference can be seen between the modal lengths of males and females. Since the intervals between the six size groups are 10 cm. or more, it is not thought that these can be based on differences associated with sex.

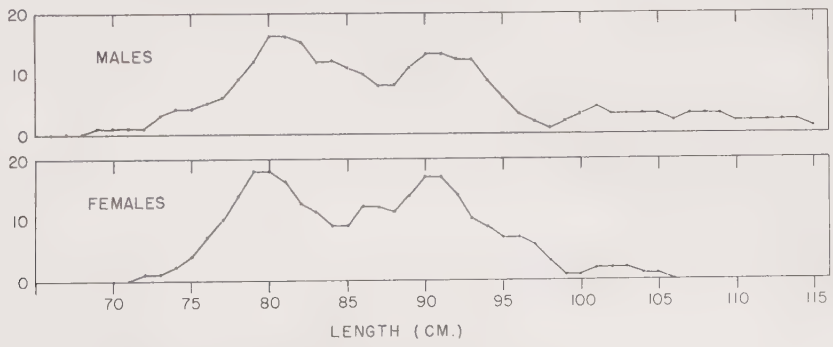

Figure 3.--Length frequencies of males and females.

from the radius of the centrum and the radii of the rings the calculated body length at the time when each ring was formed, so it appears that further examination of these results is necessary.

a_2 Comparison with the results of Uno:

Comparison with Uno's results also shows differences of 1 to 1.5 cm. However, if we take into consideration the great dispersion of the lagged difference (table 3) and the possibility that Uno's results were greatly influenced by annual variations due to the fact that they consisted of only a single value, it is thought that there is a possibility that the two sets of results are in agreement. A rejection test of the two separate results using the t-test was made, and for the interval between the 4th year and 5th year groups (II group and III group) $a > 0.3$ and for the interval between the 5th year and 6th year groups (III group and IV group) $a > 0.6$, so that it cannot be said that they do not coincide.[7/]

b. According to tables 1 to 4, the modal lengths of the several groups are located at approximately equal intervals, showing that within this size range the growth of the albacore is in a straight line or follows a curve which is nearly a straight line. However, as already mentioned, in this sea area albacore longer then 120 cm. are very rarely taken. This is not limited only to this sea area, for in other sea areas also we find hardly any fish over 120 cm. in length. Consequently it is assumed that the maximum length which albacore reach is between 120 and 125 cm. For group VI the modal length is in the vicinity of 110 cm. and the upper limit of the size range is at 115-118 cm. Accordingly this means that the growth of albacore which are almost at the maximum size which they can reach proceeds in a straight line. Since the growth of most living organisms is logistic, results of this sort may indicate that it is unreasonable to postulate the various length groups as age groups.

On the other hand, some doubt also arises as to the assumption that the maximum length of albacore is between 120 and 125 cm. If we affirm that almost straight line growth is shown up to the position of the modal length of group VI, it means that the maximum length of albacore that we can anticipate must be much greater than 125 cm. However, on the basis of the data collected up to the present, it is thought that there is rather little room to establish a hypothesis that the length which albacore can reach is greater than 125 cm.

[7/] Uno's age group 4, age group 5, and age group 6 are thought to correspond respectively to group II, group III, and group IV.

Table 6.--Relation between age and body-length

a. According to Aikawa and Katō

Age	0	1	2	3	4	5	6	7	8
Range of body-length	< 35	35 | 46	46 | 55	55 | 64	64 | 73	73 | 82	82 | 91	91 | 100	100 <

b. According to Uno

Year		1935			1936		
Age		4	5	6	4	5	6
Body-length	M	72.38	79.15	89.55	69.04	81.56	89.70
	S. D.	1.30	3.68	2.25	4.65	3.82	1.98

M and S. D. indicate mean value and standard deviation

c. It is necessary here to reconsider the ling of the normal distributions. Naturally numbers of occurrences at both ends of the tribution are few. Furthermore, in the er groups the scatter or dispersion of the gths is great. Consequently, sampling or is great, especially in the older groups. rthermore, the difficulty of estimating the dal lengths and the range of distribution of body lengths is increased, and the length ups overlap each other so that they are ficult to separate. As a result, in the older ups the fitting of normal distributions to length distribution in itself is unavoidably companied by inaccurate results. Actually, we try taking the coefficient of correlation ween the average lengths of group N of a tain year and group N + 1 of the following r[8/], the older the age group the smaller value we get. If we collate these facts h the circumstances set forth in paragraph we cannot help thinking that there is a sibility of error in the fitting of normal tributions to the older age groups.

In conclusion, according to paragraph a we cannot find any facts which would deny that at least in the case of the groups II-IV these length groups are age groups. The results can neither be said to agree nor to disagree but the absolute values of the differences are very small. Consequently it appears that there is no great obstacle for the present to treating them as age groups. According to paragraphs b and c, in the fitting of the six normal distributions, a possibility of error is indicated in the fitting to the advanced age groups. On the other hand, if there is no error in the fitting of the normal distributions, a doubt is cast upon the assumption that the six size groups are age groups. With this sort of results, it is thought that if the size groups postulated for the albacore captured by longline in the North Pacific Ocean are handled as five groups consisting of groups I to IV and an advanced age group above that, there is no obstacle to considering them as age groups. Figure 4 shows the size composition which appeared in figure 2 as the 5 length groups, I, II, III, IV and the advanced age group.

[8/] The coefficients of correlation are as follows:

Group I-II	Group II-III	Group III-IV	Group IV-V	Group V-VI
+ 0.63	+ 0.87	+ 0.64	+ 0.40	- 0.01

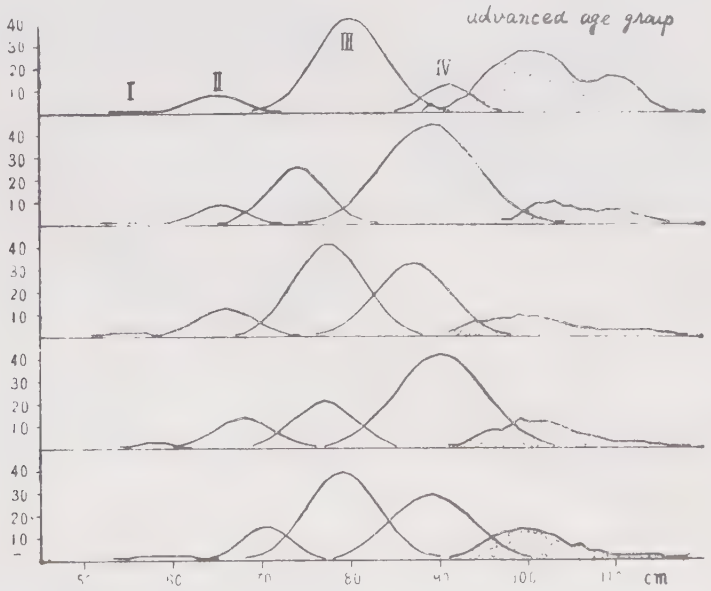

Figure 4.--Length groups of the albacore caught in the northwestern Pacific during the longline season.

Summary

The albacore longline fishing grounds which are formed in the North Pacific Ocean every year in November continue moving southward until March of the next year. The author has attempted to analyze the size composition of albacore landed from these fishing grounds by fitting normal distributions to the size composition. The results are shown in figure 2. These may be summarized as follows:

1. Six size groups appear each year. If we postulate that there are mutual correspondences among the six groups, the positions of the modes are approximately 57 cm., 67 cm., 78 cm., 89 cm., 100 cm., and 111 cm., with approximately equal intervals between the size groups.

2. The size groups which appear in the greatest numbers are those which have their modal length in the vicinity of 78 cm. and 89 cm., these two groups alternating in predominance every other year.

Through an examination of these results the following may be said:

1. A comparison was made with the results of age determinations made by Uno, and for groups II-IV it can neither be denied nor affirmed that there is agreement between the two sets of results. However, the absolute values of the discrepancies are very small.

2. It is pointed out that there is a possibility that the separation of the advanced age group is erroneous. Consequently, it is thought that if the division into groups of the albacore taken by longlines in the North Pacific is carried out as shown in figure 4, there is no great obstacle to handling them as age groups.

Albacore Studies. II. Size Composition of the Albacore Taken in the North Pacific During the Period of Northward Movement*

By

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/English title and summary/

Studies on the Albacore - II. Size Composition in the North Pacific Ground during the Period of it's Northward Migration

The area of the Kuroshio current or the North Pacific current is known as the quite excellent fishing ground of the Albacore. Albacore in this ground migrates southward during Autumn and early Spring, and is mainly caught by long-line. From Spring to Summer it migrates northward and is caught by rod and line with live bait. As to the former catch the author already reported it's size-composition (Suda 1954a). In the present, the author reports the analysis of the size-composition of the latter. The principal informations obtained by this work are as follows.

(1) Though the range of the size is confined within the limit between 50 to 100 cm during the seasons of 1951 and 1954, there are the remarkable annual fluctuations.

(2) The number of length-groups are not fixed by the seasons. 3 or 5 length-groups appear in each season from 1951 to 1954.

(3) The modal length of each length-group shows remarkable annual fluctuation. (Table 1)

(4) The relative abundance of each length-group is very unstable as shown in Table 2. In most cases, the most dominant length-group occupies the overwhelming proportion.

Such a size-composition of the northward migrating Albacore differs from that of southward migrating one as follows.

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(1) Such advanced age groups* as seen in the southward migrating fishes do not appear in these which migrate northward.

(2) Size-composition of the northward migrating ones shows the remarkable annual fluctuation, therefore it is able to say that it is much more unstable than that of the southward migrating.

(3) The dispersion of the length frequency of the northward migrating ones is much more small than that of the southward migrating ones.

Then differences between the two groups seen to be based on ecological differences of them other than the difference of fishing method. In spite of these differences, the author hypothesized that there will be some relations between these two groups on a basis that the body-length of the most dominant size-groups are less than 100 cm in both migrating groups.

*Age is not determined; larger than 90 cm. (Suda 1954a).

/end of English summary/

The albacore exploited by the longline fishery, which move southward in the autumn and winter between 140°E. and 180°, cease their southward movement each year around March north of the Subtropical Convergence in the vicinity of 28°N., and in April, while showing some signs of northward movement, they suddenly disappear. As if to take their place, the pole-and-line albacore fishery begins, with its main fishing season from May to June. During this period the fishery moves northward between 140°E. and 160°E. The author has attempted to analyze the size composition of these northward-moving albacore and also to compare it with the size composition of the southward-moving albacore which are taken on longlines (Suda 1954a). The data employed resulted from the studies of landings made by the Nankai Regional Fisheries Research Laboratory at the Tokyo and Yaizu fish markets1/.

Size of the Northward-moving Albacore

According to the data for the period of 1951 to 1954, the length range of the northward-moving albacore taken by pole and line is approximately 50-100 cm.2/ There were almost no specimens over 100 cm. long (solid line in fig. 1). However, within this range the lengths show conspicuous changes from year to year. These variations are particularly marked in the fish between 50 cm. and 70 cm. long, which in some years appear prominently and make up an important element in the albacore catch but in other years hardly appear at all. Fish in the 70 cm. to 100 cm. length range appear every year and are the most stabilized portion of the northward-moving albacore. It is noted that the upper limit of length coincides for all years at about 95-100 cm.

The broken line in figure 1 shows the results of fitting suitable normal distributions to the length frequency curve of the northward-moving albacore3/. Conspicuous variations are shown from year to year in the modal lengths of the several length groups, and it is difficult to determine which groups are analogous. In order to make this determination, the size composition by months for the period from November 1950 to July 1954 was obtained and an attempt was made to follow the transition of the modes. Figure 2 is the size composition by months of not only the northward-moving albacore but also including the southward-moving fish. In most cases the positions of the modes are not clear for the fish over 90 cm. long, so they have been omitted. As can be seen from figure 2, length data for the

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1/ Measurements were made as follows:

Year	Voyage sampling ratio	Voyages surveyed	Fish sampling ratio	Fish measured
1951	as many as possible	40	as many as possible	9,043
1952	0.25	80	0.20	54,893
1953	0.50	127	0.10	25,200
1954	1.00	105	0.10	13,230

2/ In June 1951 some fish 30-37 cm. long were measured, but there was only one large catch of albacore of this size. Their average length (139 fish measured) was 34.6 cm., with a standard deviation of 1.25 cm.

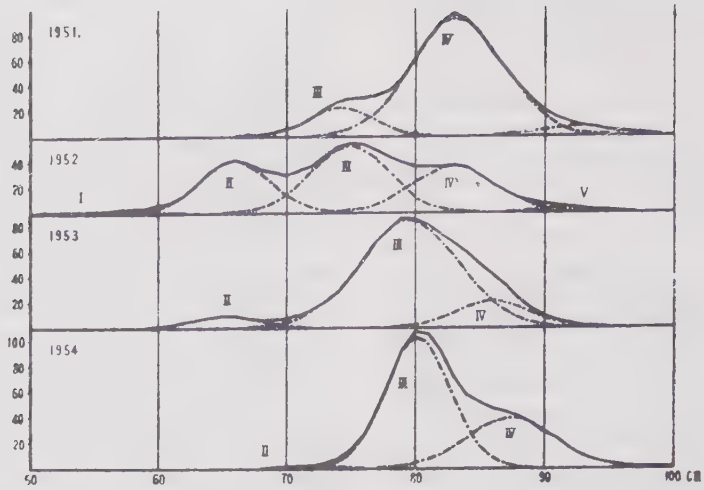

Figure 1.--Size composition of northward-moving albacore. The solid line represents the length frequency curve (shown by permillage), and the estimated length groups are shown by the broken line.

period from summer to autumn are completely lacking, and it is impossible to get a definite grasp of the process of growth. Several growth patterns can be postulated, but the assumption that "the series of modes to which the same number has been given shows the growth of a certain age group" gives a value for 1 year's growth that is nearest to the intervals between length groups. This hypothesis is thought to be the most adequate, provided that adjacent length groups are considered to be 1 year apart in age.[4/] In this case, the growth of the albacore is not uniform throughout the year, and the rate of growth from summer to autumn turns out to be markedly lower. However, it cannot be denied that there is a possibility that a certain age group which has grown as indicated by a certain numbered modal series may in the following longline season (November-December) follow the growth shown by the mode with the next lower number. There is need of some method for ascertaining this. In this case, 1 year's growth would always be considerably greater than the interval between length groups, in fact, it would be nearer to twice that interval. Consequently, there would be very little possibility of adjacent length groups being age groups 1 year apart. If we postulate that growth takes place as indicated by following the series of modes to which the same

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[3/] For the method see my "Size composition of the albacore taken in the North Pacific during the period of southward movement," Bull. Jap. Soc. Sci. Fish. 20(6), 1954. The results of chi-square tests of the fitting of normal distributions to the length frequency curve for northward-moving albacore are as follows:

Season	Degrees of freedom available	Degrees of freedom lost	Degrees of freedom left	Chi-square
1951	13	10	3	27.90
1952	19	16	3	128.47
1953	14	10	4	30.90
1954	11	10	1	28.91

[4/] See my paper previously cited. From the results of separating a number of length groups by the fitting of normal distributions on the length frequency curve for longline-caught fish, it appears that there is no obstacle to considering adjacent length groups as having a 1-year age difference.

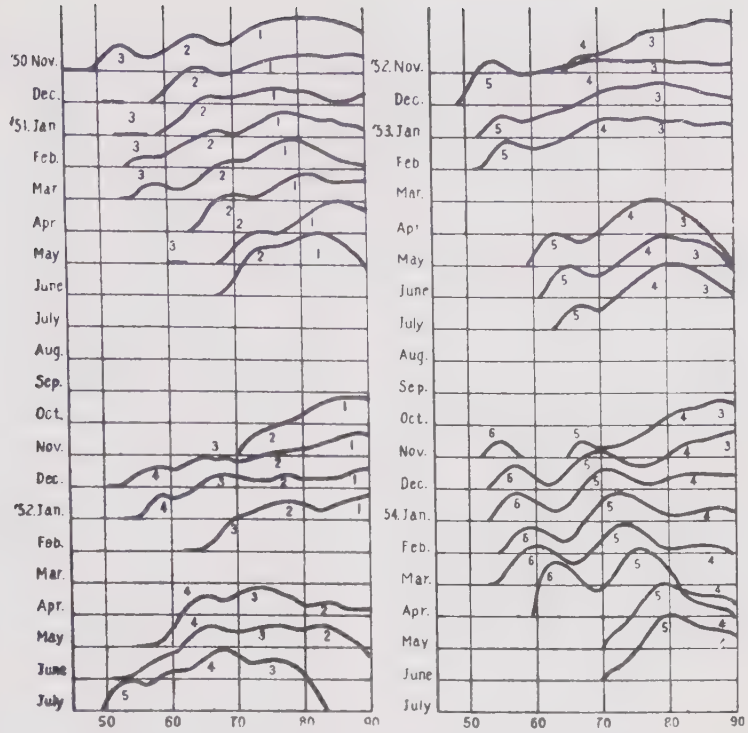

Figure 2.--Size frequency of the albacore caught on the North Pacific ground, by months (northward- and southward-moving albacore combined). The series of figures represents the transition of the modes. The ordinate represents the frequency in logarithms.

number has been attached in figure 2, and make the various length groups correspond as shown below, each vertical column can be considered as representing a single age group.

1951			2	1
1952	5	4	3	2
1953		5	4	3
1954			6	5	4
	I	II	III	IV

The various groups are made to correspond in this way, and then they are numbered in order beginning with the smallest, Group I, Group II, etc. (Group V, which has a modal length over 90 cm., is not shown in figure 2.) According to figure 2, these length groups correspond respectively to Group I, Group II, . . . Group V of the southward-moving albacore which are taken on longlines from autumn of one year through into the next year. Table 1 shows the modal length of each length group, and table 2 the proportion of each length group.

Table 1.--Modal length of each length group

Season	I	II	III	IV	V
1951			74.2	83.3	92.5
1952	55.5	66.0	74.9	83.8	91.5
1953		65.4	79.5	86.0	
1954		72.0	80.2	87.3	
M ± S. D.	55.5	67.8 ± 2.98	77.2 ± 2.67	85.1 ± 1.63	92.0 ± 0.50

Table 2.--Proportion of each length group (shown by permillage)

Season	I	II	III	IV	V
1951			139	819	43
1952	14	283	393	294	14
1953		57	802	139	
1954		10	652	337	
M ± S. D.	3.5 ± 6.1	87.5 ± 114.9	496.5 ± 253.0	397.3 ± 254.3	14.3 ± 17.5

In the following paragraphs some characteristics of the length groups making up the northward-moving albacore will be examined:

(1) The length groups appearing in the northward-moving albacore number three to five, the number varying from year to year. The only length groups which appear consistently throughout the 4 years are Group III and Group IV. In terms of the proportion they occupy, all of the groups show wide variations from year to year, the average magnitudes being greater than 50 percent. The fluctuation is particularly conspicuous in Group II, which in some years is an important element and in others does not appear at all.

(2) The 4-year averages of the modal lengths of each group are respectively 55.5 cm., 68 cm., 77 cm., 85 cm., and 92 cm., but the fluctuations in the values from year to year are great, and the spread between the largest and the smallest extremes is as much as one-half the interval between length groups for all of the groups. The intervals between the several length groups, with the exception of groups I and II, are about 2 cm. smaller than in the case of the southward-moving albacore (Suda 1954a). The values of the modal lengths themselves are in approximate agreement with those of the southward-moving albacore. These facts seem to be ascribable in large part to the characteristics of the growth and also to the marked variations from year to year. The upper limit of the length range of the pole-and-line albacore coincides each year at 95-100 cm., but this position is sometimes the upper limit of Group IV and sometimes the upper limit of Group V. It is thought that this is determined rather mechanically and without relation to such things as the positions of the length groups and the range of the distribution, since it is believed that the upper limit of size of fish which can be taken in large numbers by pole-and-line fishing may be in this region. In this case, we must consider the possibility that only the comparatively small fish of Group V may appear in the catch.

(3) There is no consistent trend of predominance of any group throughout the 4 years. Cases of predominance of Group III are most numerous, but there are also examples of predominance of Group IV. In most cases the predominant group is overwhelmingly so, but there are also cases in which it does not rise greatly above the others. There are no signs of the alternation of dominant groups every other year, as seen in the southward-moving albacore.

When we consider, over a number of consecutive years, the length groups which make up the northward-moving albacore, it is difficult to detect any regularity or resemblances in the composition of the length groups from year to year, except for the fact that Groups III and IV appear every year. It is thought that there is a deep connection between these phenomena and the conspicuous fluctuations in the annual catch of the northward-moving albacore.[5/]

Comparison of the Size Compositions of the Southward-moving (Longline) Albacore and the Northward-moving (Pole-and-Line) Albacore

As stated in the preceding section, the size composition of the northward-moving albacore shows violent annual fluctuations. When it is compared with that of the southward-moving albacore, some conspicuous points of difference

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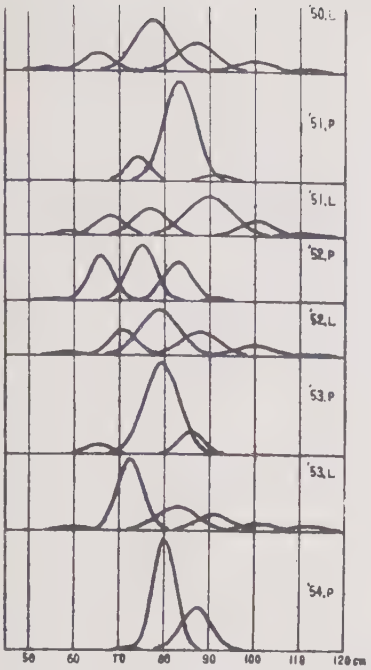
5/ According to the data of the Statistics and Survey Division of the Ministry of Agriculture and Forestry, the albacore landings for the period of May to July of each year were as follows: 1951 - 1,876,000 kan /7,757.26 tons/, 1952 - 11,556,000 kan /47,784.06 tons/, 1953 - 8,428,000 kan /34,849.78 tons/, 1954 - 5,841,000 kan /24,152.54 tons/.



gure 3.--Comparison of the size composition of the northward- and southward-moving albacore. The curves represent the length groups. Those marked "L" are the longline-caught (southward-moving) fish; those marked "P" are the northward-moving fish taken on pole and line.

e indicated. Figure 3 shows the size of the acore taken at 140°E. to 160°E., divided ording to the periods of northward and thward movement. According to this ure,

(1) The length range of the southward-ving albacore is 50 cm. - 120 cm., while t of the northward-moving fish is 50 cm. - cm., or about 20 cm. narrower (see Suda 4a). Consequently, Group VI does not ap-ar at all in the northward-moving albacore, d even Group V barely appears in some ars. The group of large fish of 100 cm. - 0 cm. (Group V and Group VI) which is seen the southward-moving albacore is almost sent from the northward-moving fish. 6/

(2) Even when Groups V and VI are itted and only the fish under 100 cm. in ngth are considered, we see rather funda-ental differences between the two. Whereas the southward-moving albacore there are ur length groups appearing repeatedly year after year, with a strong tendency for Group III and Group IV to increase and decrease alternately every other year, in the northward-moving albacore the number of length groups appearing varies randomly (2-4 groups) 7/. The difference between the two can be expressed as "stability of the southward-moving albacore as contrasted with instability of the northward-moving albacore."

(3) The concentration of sizes is much more marked in the northward-moving fish. For the period of 1951-1954, with the exception of 1953, almost all of the catch was concentrated within a range of about 30 cm. In the southward-moving fish we see no single length group which makes up a majority of the whole, but in the northward-moving fish, in most years, we see groups which overwhelmingly predominate over the others.

When we consider the relationship between these two groups of albacore, it is thought that some of these points of difference may be of important significance in marking a separation between them. However, even though some points of separation may exist in the size composition of the two groups, the fact that in both the southward- and northward-moving albacore the

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6/ Uda and Tokunaga (1937), dealing with the size of the albacore taken in the winter longline fishery, have reported that those caught in areas closer to Japan are smaller and those taken farther off shore are larger. It is conceivable that the fact that the pole-and-line fishing grounds are limited to waters comparatively close to Japan may be the reason for the size difference between the fish taken while moving northward and those taken while they are moving southward. However, figure 3 shows a comparison of the sizes of these two groups of fish taken between 140°E. and 160°E. longitude, and the difference between them is still clear even when the area is limited in this way.

7/ If we do not limit the area considered to 140°E.-160°E., but broaden it to cover 140°E.-180°, the regularity which we see in the composition of the southward-moving albacore is even further heightened. That is, Group III and Group IV each increase on a 2-year cycle. Group III in even-numbered years and Group IV in odd-numbered years, with the result that the two groups alternate in predominance every other year. The fact that this rule breaks down and becomes less clear as the consideration is limited to areas closer to the Japanese coasts was reported at the Tokyo meeting of the Japanese Soceity of Scientific Fisheries in April 1954.

fish under 100 cm. long make up the overwhelming proportion is an outstanding point that they have in common. Furthermore, when we take into consideration the fact that, despite differences of season and fishing method, the fishing grounds for the two are formed in the same sea areas, it is probably correct to think that a considerable portion of the northward-moving albacore are a legacy from the southward-moving fish.

The tendency for pole-and-line fishing vessels to concentrate on certain particularly productive grounds is very strongly marked. Consequently, the tendency for the peculiarities of the catch of certain grounds to extend an influence over the whole is thought to be especially strong in the case of the pole-and-line catch. Also, as was remarked earlier, the upper limit of the size of fish that can be taken in large numbers by pole-and-line fishing is thought to be in the neighborhood of 100 cm.8/

We cannot deny that such peculiarities of the pole-and-line fishing method may be a cause of the difference in the size composition of the two groups. On the other hand, if we consider that around April and May large albacore of 90-120 cm. break off from the northward-moving group and cross the Subtropical Convergence to the southward (Suda 1954b), it also cannot be denied that the cause of the extraordinary scarcity of this large size-group in the catch of northward-moving albacore may be a decrease in the numbers of the group itself.9/ Furthermore, with regard to the point that the size composition of the northward-moving albacore shows highly irregular changes from year to year, we might also consider the fact that the pole-and-line fishing grounds are formed within the limits of a comparatively small sea area. However, if we take into consideration the point that the size composition of the southward-moving group captured within the same area is quite stabilized, it is believed to be important to think of this phenomenon in relation to seasonal changes in the population.

Finally, it cannot be denied that in the differences of size composition seen between the northward- and southward-moving albacore there may be a factor of seasonal changes in the population itself, in addition to such causes as the peculiarities of the fishing method.

In conclusion, the author wishes to express his thanks to all of the staff members of the Nankai Regional Fisheries Research Laboratory, who gathered the data, to Miss Michiko Momota, who made the drawings, and to Director Nakamura and Section Chief Yabe, for their constant guidance.

8/ There may be a possibility that large size-groups are included among the northward-moving albacore but that they are not captured.

9/ Fish of the 90-120 cm. size range are also seen among the albacore taken by long-line during the period of northward movement, however, they are far fewer than during the period of southward movement, and indeed vestigial.

Bigeye Studies. I. Size Composition of the Bigeye on the North Pacific Fishing Grounds (and Especially on the Alternate-year Cycle in the Size Composition)*

By

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/English title and summary/

Biology of the Big-Eyed Tuna, Parathunnus mebachi (Kishinouye) - I. Length Frequency of the Big-Eyed Tuna Caught in the North Pacific with Special Reference to Biennial Frequency

The present paper deals with analysis of length frequency of the big-eyed tuna, Parathunnus mebachi (Kishinouye), in the light of various hypotheses on the basis of data obtained from length determination conducted at several landing places and from information furnished by tuna fishing boats. Number of the samples used for the study were caught in several parts of the North Pacific, extending north of latitude 26°N., and between longitudes 130°E. and 165°W. in five successive seasons from October to March during a period of 1948 through 1953 (Table 1). For determination of the length, the distance from the tip of the snout to the median part of the caudal fork was used.

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1. The following has been revealed in comparison of the length frequency by fishing area and season.

A. As far as the samples caught in the same season are concerned, modes of the length frequency are, as a rule, found in an agreement with each other, almost regardless of fishing areas (Fig. 1).

B. When the modes formed in different seasons are compared, variance in their presentation is remarkable depending on fishing areas. However, it has been observed that characteristic features prevailing throughout the period under study indicate dominant modes, some formed by smaller fish caught in the western areas, and the other by larger fish in the east.

This can be interpreted in other words that the small sized fish were as abundant in the western part just as the large fish in the east (Fig. 2). Judging from the facts stated above, it is hardly possible to consider that the population of the big-eyed tuna migrating to the fishing grounds under discussion would consist of more than two groups belonging to entirely independent races.

C. In regard to annual discrepancy in the modes, attention has been drawn to the fact the modes tend to form with frequency occuring every other year (Fig. 3).

2. As probable causes of the annual fluctuation in the modes three hypotheses have previously been established by Nakamura, Shimura and Yabuta 1):

(i) Difference in annual propagation;

(ii) Difference in annual growth rate;

(iii) Difference in annual course of migration.

In the examination of hypothesis (i), a series of assumption (A, B, C) have been introduced in connection with successive transformation of the modes which is likely involved in the course of growth. The assumption has been derived from length frequency by season (Fig. 4) as tabulated below:

Fishing Season

Assumption	1948	1949	1950	1951	1952
(A)	a_1A_1	$\rightarrow A'b'$	$\rightarrow B_2$	$\rightarrow C''$	$\rightarrow D_3$
(B)	B_1	$\rightarrow C'$	$\rightarrow D_2$		
(C)			a_2A_2	$\rightarrow A''b''$	$\rightarrow B_3$

As the result we have reached the conclusion that hypothesis (i) is more reliable than the others so far as progression of the modes in the way assumed above appears reasonable. Whereas, hypothesis (ii) can not be, at least, a decisive factor influencing the mode progression. Because it is difficult to draw rational interpretation of the phenomenon from this hypothesis. On the other hand, there is some room where hypothesis (iii) may be accepted as reasonable one, provided that the fish should take the same migratory route every two years.

3. On the basis of the above assumption, as it seems to be most feasible for the present study, ecological mechanism influencing the biennial frequency has been considered. In consequence, notable fluctuation taken place in abundance of age groups every second year is found to be likely a major factor supporting this particular phenomenon. At the same time, it has been pointed out that there is more or less disagreement between the modes formed in different seasons when examined in the light of age-group, which might likely be ascribable to the ecological mechanism as well.

4. For the purpose of proceeding the study further on the basis of the assumption (A, B, C), consideration has been paid on two factors: one being the stage from which the biennial frequency might have developed; the other, ecological mechanism involved therein. It is almost certain that the initial stage for the frequency would have occurred before the fish developed to age groups a_{1-3}. However, an alternate question that remains to be solved lies in whether the biennial frequency was resulted from:

a) causes accumulated in the course of growth;

b) or a cause which had a decisive effect on the fish at a certain stage of the development.

Judging from general circumstances for marine life, the latter cause (b) is more likely to take place than the former. In addition, there

are sufficient reasons to assume that the initial factor would come in effect at an earlier stage of the fish under development. This assumption appears in an agreement with hypothesis (i). Even if the frequency would start once at an early developmental stage, however, the ecological mechanism accountable for the phenomenon must have been of complex rather than simple one. For this reason, when propagation of the fish is to be discussed as a component of the mechanism influencing the frequency, it is necessary to take into consideration such various environmental factors as to be supplied into different parts of the fishing regions, i.e., the northern hemisphere of the Pacific, its counterpart in the south, and the Indian Ocean.

5. So far as the present study goes, it is premature to decide whether or not the biennial frequency will continue to make an appearance in the future. But if it does, knowledge and data we obtained so far will certainly serve as an important suggestion from which advancement of study on the big-eyed tuna is expected.

/end of English summary/

Nakamura, Kamimura, and Yabuta (1953) have already made a comparison of the length frequency composition of the catch of bigeye tuna from the North Pacific fishing grounds in the two periods of December 1948-March 1949 and October 1949-March 1950, and they have pointed out clearly discrepancies in the positions at which the modes appeared in these two seasons and in the manner of their appearance, the former having modes centered at 85-88 cm., 121-124 cm., and 149-152 cm., while the latter had conspicuous modes centered at 93-96 cm. and 137-140 cm., with another somewhat obscure mode centered at 105-108 cm. They have considered the following three possible causes of these discrepancies:

1) Differences from year to year in growth rates

2) Differences from year to year in recruitment

3) Differences from year to year in migrational phenomena

The present authors have made a comparison of the length measurement data for the three periods of October 1950-March 1951, October 1951-March 1952, and October 1952-March 1953, together with the older data mentioned above, and have found some extremely interesting phenomena, which they report here.

Collection of the data used in this study was all planned and executed by the High Seas Resources Section of the Nankai Regional Fisheries Research Laboratory. The term "North Pacific fishing ground" used in this paper means the area from 130°E. longitude to 165°W. longitude and north of 26°N. latitude. The authors herewith express their thanks to Dr. Nakamura, director of this laboratory, and to Dr. Yabe, chief of the High Seas Resources Section, for their guidance in this study.

Data

The measurements, taken with wooden calipers, are the shortest distance from the tip of the snout to the bottom of the fork of the tail. Measurements were read to the nearest centimeter, units below 1 cm. being dropped. In this study the data were arranged in 4 cm. groups. As far as sampling is concerned, the first unit of selection was the vessel and the second unit of selection was the fish. The percentage of selection at the first level did not follow any particular standard, the greatest number of boats possible under the circumstances being sampled. At the second unit of selection the original objective was to measure all fish, but where this was not possible the percentage of selection was modified to suit the circumstances.

Table 1 shows the numbers of fish measured by month and area:

I. Length Composition

Figure 1 shows the length composition by years* and by sea area. The most striking features of this figure are the appearance in each year of what clearly can be considered modes, and the fact that a tendency can be detected for the positions at which the modes appear to coincide generally in the different sea areas. The positions of the modes were: in 1948, 69-80 cm., 81-96 cm., 113-132 cm., and 145-164 cm.; in 1949, 89-100 cm., 101-116 cm., and 132-148 cm.; in 1950, 85-100 cm., 109-128 cm., and 141-164 cm.; in 1951, 89-104 cm., 105-124 cm., and 129-152 cm.; and in 1952, 89-104 cm., 113-136 cm., and 141-160 cm. As for

*Hereafter the periods of measurement will be referred to as "years".

Table 1.--Number of ships and fish sampled by month and by area.
Figures enclosed in parentheses show the number of ships

*: No data available.

1948-'49 (1948 season)

Year and month		130° to 140° E.	140° to 150° E.	150° to 165° E.	165° to 180° E.	East of 180° E.	Total	Landing place
1948	12	- *	234(9)	951(25)	307(5)	-	1,492(39)	
1949	1	-	282(11)	588(11)	467(7)	-	1,337(29)	Tokyo
	2	-	88(3)	-	-	-	88(3)	
	3	-	15(2)	90(2)	357(3)	-	462(7)	
Total		-	619(25)	1,629(38)	1,131(15)	-	3,379(78)	

1949-'50 (1949 season)

Year and month		130° to 140° E.	140° to 150° E.	150° to 165° E.	165° to 180° E.	East of 180° E.	Total	Landing place
1949	10	-	-	901(11)	269(5)	-	1,170(16)	
	11	-	237(1)	198(5)	250(5)	196(1)	881(12)	
	12	-	537(11)	-	614(10)	-	1,151(21)	Tokyo
1950	1	-	365(8)	17(1)	334(11)	-	716(20)	
	2	-	278(11)	36(2)	227(5)	69(1)	610(19)	
	3	-	190(5)	-	156(3)	100(2)	446(10)	
Total		-	1,607(36)	1,152(19)	1,850(39)	365(4)	4,974(98)	

1950-'51 (1950 season)

Year and month		130° to 140° E.	140° to 150° E.	150° to 165° E.	165° to 180° E.	East of 180° E.	Total	Landing place
1950	10	-	42(1)	1,052(6)	65(1)	299(2)	1,458(10)	
	11	58(1)	809(8)	3,597(17)	-	72(1)	4,536(27)	
	12	-	1,122(7)	370(3)	450(2)	-	1,942(12)	Tokyo
1951	1	-	907(12)	260(5)	624(3)	-	1,791(20)	
	2	308(3)	1,285(22)	234(4)	252(2)	-	2,079(31)	
	3	230(3)	636(11)	-	-	-	866(14)	
Total		596(7)	4,801(61)	5,513(35)	1,391(8)	371(3)	12,672(114)	

Table 1.--Number of ships and fish sampled by month and by area.
Figures enclosed in parentheses show the number of ships (cont'd)

1951-'52 (1951 season)

Year and month		130° to 140° E.	140° to 150° E.	150° to 165° E.	165° to 180° E.	East of 180° E.	Total	Landing place
1951	10	-	-	237(3)	-	-	237(3)	
	11	-	-	1,794(13)	-	-	1,794(13)	Tokyo
	12	-	161(4)	1,005(8)	106(2)	-	1,272(14)	Yaizu
1952	1	309(4)	966(21)	412(10)	919(7)	-	2,606(42)	
	2	116(3)	128(4)	107(2)	127(1)		478(10)	
	3	-	-	-	270(1)	-	270(1)	
Total		425(7)	1,255(29)	3,555(36)	1,422(11)	-	6,657(83)	

1952-'53 (1952 season)

Year and month		130° to 140° E.	140° to 150° E.	150° to 165° E.	165° to 180° E.	East of 180° E.	Total	Landing place
1952	10	40(2)	-	2,252(14)	1,392(7)	-	3,684(23)	
	11	306(36)	-	4,742(29)	314(3)	-	5,362(68)	Tokyo
	12	2,156(47)	68(6)	1,491(17)	500(5)	-	4,215(75)	Yaizu
1953	1	1,832(32)	1,078(25)	832(24)	904(10)	1,294(6)	5,940(97)	Katsuura
	2	1,162(26)	416(12)	536(12)	311(5)	731(6)	3,156(61)	
	3	373(15)	-	-	-	-	373(15)	
Total		5,869(158)	1,562(43)	9,853(96)	3,421(30)	2,025(12)	22,730(339)	

the manner in which these modes appear, it is clear from the figure that this differs markedly from area to area. If we follow individual modes through the various sea areas, we can recognize various degrees from clear existence to almost no indication of existence. This sort of variation arises from differences among the sea areas in the relative abundance of large and small fish.

In order to compare differences of this sort, figure 2 has been prepared, showing the yearly length composition by sea areas. According to the figure, the modes made up of groups of smaller fish predominate in the more westerly areas, while the modes made up of larger fish are more predominant in the easterly areas. This sort of relationship is even more clearly recognizable when the data are separated by areas and by years. In other words, the proportion of the smaller size groups is greater in the more western sea areas, and that of the larger size groups is greater in the more eastern sea areas.

Cases can also be seen in which there are slight displacements in the positions of the modes as between sea areas. To cite conspicuous examples of this sort in figure 1, there are the modes at 109-128 cm. in 1950, 89-104 cm. and 129-152 cm. in 1951, and 113-136 cm. in 1952. In particular, for the mode at 113-136 cm. in 1952 there is a pronounced displacement as between the area of 150°-165°E. and the area east of 180°. If we examine this situation in view of the monthly distribution of the measurements as shown in table 1, we see that the measurements for the former were taken mostly in the first half of the measuring period, whereas the measurements for the latter were taken entirely within the last half of the period. It is presumed that this discrepancy in the time of measurement is part of the reason for the displacement of the mode. However, a rather

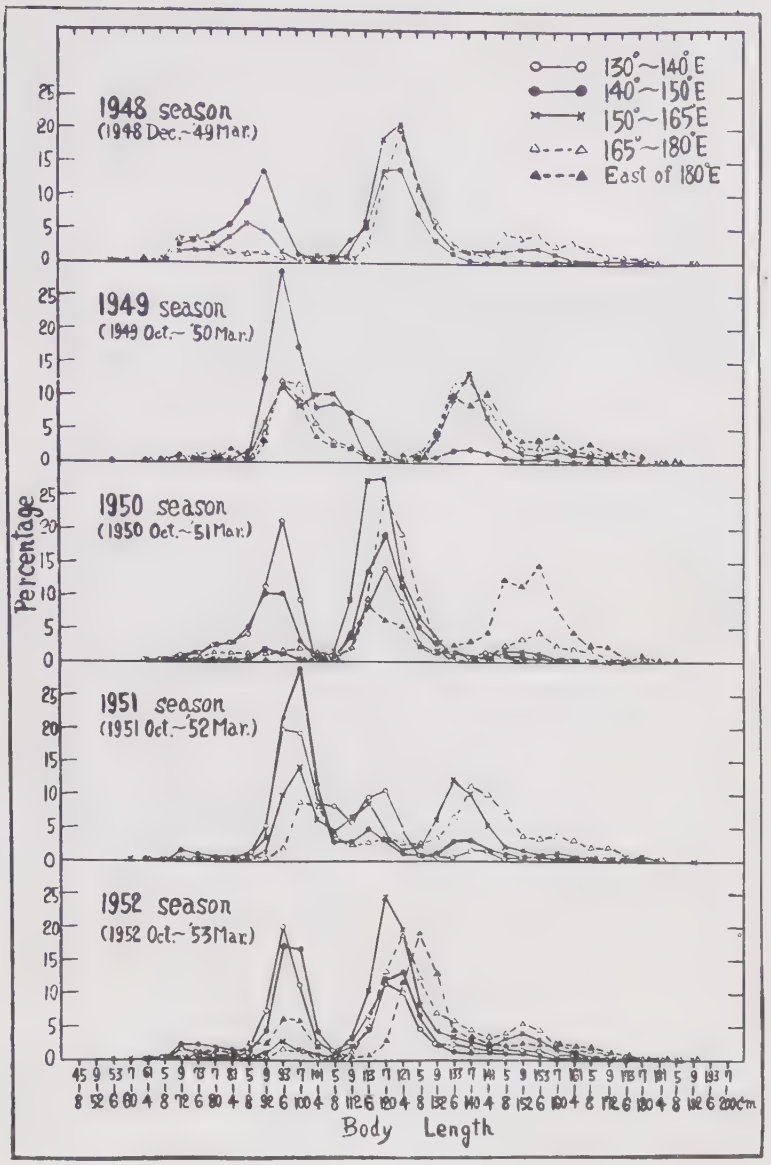


Figure 1.--Length frequency by fishing season.

pronounced displacement can be seen in the same mode as between the area of 140°-150°E. and the area east of 180°, and here there was almost no difference in the period at which the measurements were taken. Looking at it in this way, it is not possible to ascribe all the displacements of the modes for the different sea areas to differences in the periods at which the measurements were taken. If we consider the four examples of displacement of the modes in different sea areas already cited above, we can see that in general there is a tendency for the mode to be displaced to the right in the areas east of 165°E. and to the left in the areas west of that longitude. This phenomenon is probably worthy of note in that it suggests the existence of minute differences in the modes depending on the sea area. However, the displacements of this type are extremely small by comparison with those between the modes in different years, as will be set forth next.

Figure 3 shows the length composition by years, the even-numbered years being represented by solid lines and the odd-numbered years by broken lines. As is clear from the figure, there is a considerable degree of similarity

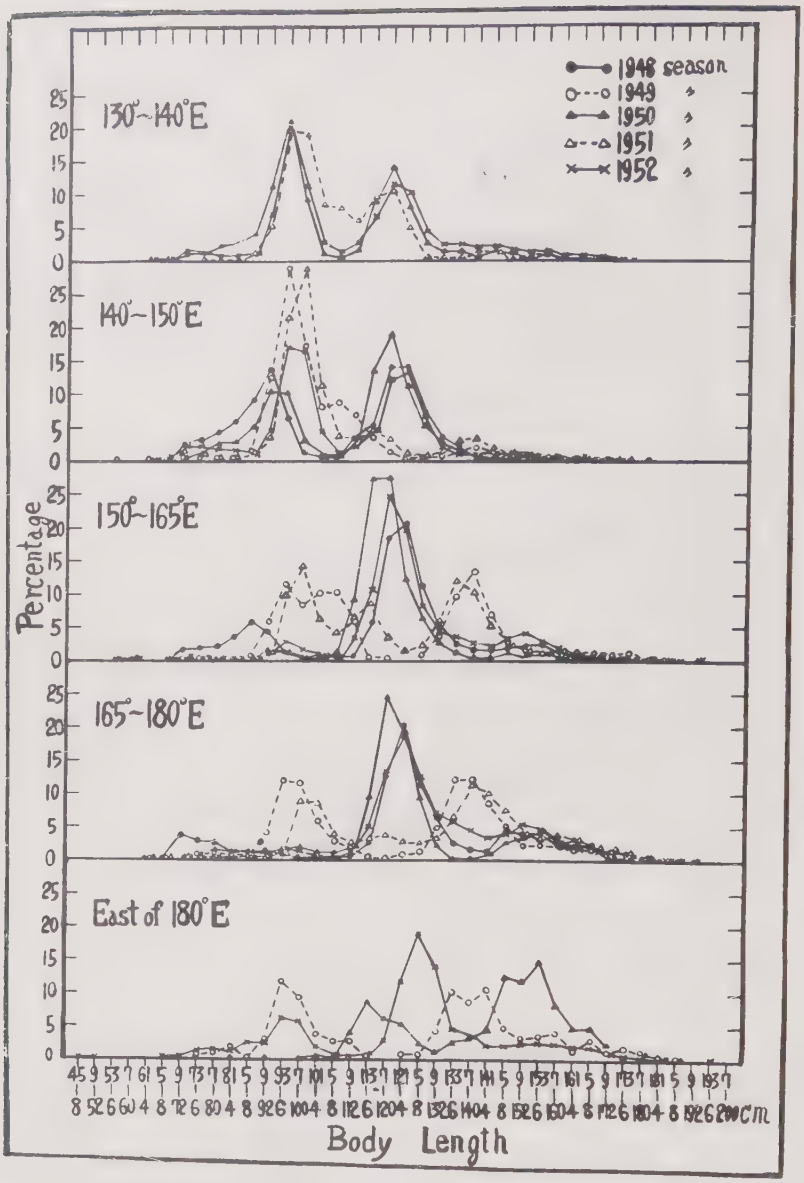


Figure 2.--Length frequency by fishing area.

among the years of each group, but there are conspicuous discrepancies between the two groups. To state it concretely, it is probably possible to point out the existence of biennial cyclical phenomena in the positions at which the modes appear and in the degree to which they appear. If we try to examine these phenomena in figure 2, where the data are presented separately by sea areas, they are unclear in the area of 130°-140°E. and east of 180°, where data are scarce, but they are clearly discernible in all of the areas for which there is much data, 140°-150°E., 150°-165°E., and 165°E.-180°. There are many points which should be examined from various angles with regard to the existence of a biennial cycle, and these points will be taken up below.

The matters pointed out above are all phenomena which appeared from the data, and it is thought that such things as the general correspondence of the positions of the modes as between the several sea areas, and the evidence of common tendencies in different years as regards the relative strength with which the modes appear in different sea areas can hardly be thought to be accidental agreements arising from defects in the data, and can be considered

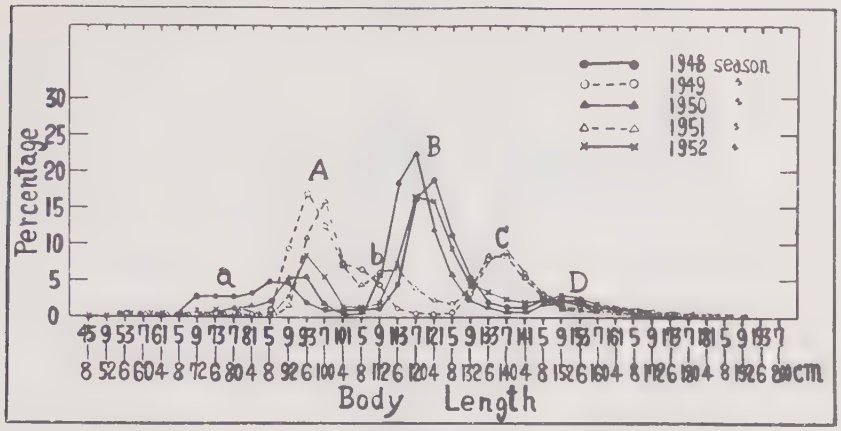


Figure 3.--Aggregated length frequency by fishing season

to reflect the actual composition of the schools that occur in the various sea areas. It can probably be concluded, if there are no errors in this hypothesis, that there is a strong possibility that the population of bigeye inhabiting the North Pacific area is composed of schools belonging to a single stock. At least, it seems that there is very little possibility that they are made up of two or more sharply differentiated racial strains. However, there are examples where small discrepancies can be detected in the positions at which the modes appear in the different sea areas, and it is thought that there is room for further study of various points concerned with the finer internal organization. These points the author would like to take up when the data have been amplified.

II. Observations on the Shifting of the Modes from Year to Year

Nakamura, Kamimura, and Yabuta (1953) have already advanced the three hypotheses mentioned above in connection with the phenomenon of the conspicuous discrepancies from year to year in the positions at which the modes appear and in the degree of their appearance. These hypotheses are:

1. Differences from year to year in the growth rate
2. Differences from year to year in recruitment
3. Differences from year to year in migrational phenomena

We will continue our examination of this subject by taking up these hypotheses one at a time in the order 2, 1, and 3.

Hypothesis 1 - Differences from year to year in the amount of recruitment

If it is postulated that a difference from year to year in the amount of recruitment is the main factor in the shifting of the modes, it should be possible to detect through the variations in the modes phenomena connected with growth. Contrariwise, if it is possible to ascertain the existence of phenomena related to growth from the group of phenomena related to the shifting of the modes from year to year, it can be concluded that the validity of the above-mentioned hypothesis will be strengthened. At least it can probably be said that it will be impossible to discard this hypothesis. We will attempt to examine the data directly from this point of view.

Figure 4 shows the body length composition split up by years. Assuming first of all that the schools which made up the modes a_1A_1 in 1949 have returned to the fishing grounds year after year, if we try to relate the discrepancies in the modes to growth which has taken place during this period, it is thought most natural to try to establish the following sort of postulate from the inter-relationships among the positions at which the modes appear: a_1A_1 (1948) $\longrightarrow$ A'b' (1949) $\longrightarrow$ B_2 (1950) $\longrightarrow$ C'' (1951) $\longrightarrow$ D_3 (1952).... (A)

The main difficulty with this assumption is in the form of the modes or in other words in the degree to which they appear, for incompatible relationships can be seen between a_1A_1 and A'b' and between A'b' and B_2.

If we try for modes B_1 and a_2A_2 the same sort of postulation as for (A),

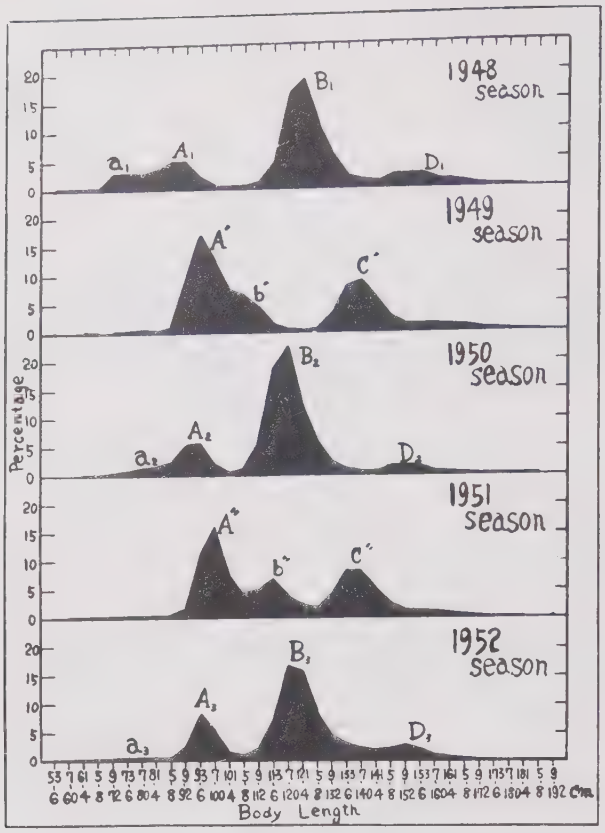


Figure 4.--Length frequency by season with noted modes.

B_1 (1948) ⟶ C' (1949) ⟶ D_2 (1950) .... (B)

a_2A_2 (1950) ⟶ A''b'' (1951) ⟶ B_3 (1952).... (C)

These relationships can be established. However, the same difficulty exists with regard to (c) as for (A). We shall investigate further to try to find out whether the difficulties pointed out for assumptions (A) and (C) are of a nature such as to overthrow these assumptions completely or whether they are of such a nature that a reasonable explanation can be given for them provided certain conditions are fulfilled. For convenience in the explanation the problems will be divided into two: (a) a_1A_1 ⟶ A'b' and a_2A_2 ⟶ A''b'' (b) A'b' ⟶ B_2 and A''b'' ⟶ B_3

On problem (a):

A'b' is thought to be compounded of two groups shown by A' and b'. In the same manner a_1A_1 can hardly be thought, in view of the form, to be a single mode, and it is probably valid to think of it as being compounded of two groups shown by a_1 and A_1. If we take it that this assumption is correct, a_1A_1 and A'b' will be understood to have no particular inconsistent relationship in their essential composition. The same sort of assumption is established with regard to the relationship between a_2A_2 and A''b''. The point that needs to be noticed here in the comparison between A'b' and A''b'' is that whereas the displacement between A' and b' in the former is small, that between A'' and b'' in the latter is relatively great. However, this sort of difference is not fundamentally in opposition to the point that they are made up of two groups as stated above. Consequently, it can probably be thought that the elements which prevent the rational establishment of the assumptions a_1A_1 ⟶ A'b' and a_2A_2 ⟶ A''b'' arise chiefly from differences in the relative abundance between the two different groups.

Table 2 shows the relative abundance between the two groups mentioned above. As far as the division into two groups is concerned, there is no particular problem in the case of

Table 2.--Relative abundance between two groups

*: No data available

Mode	Area / Group	130° to 140°E.	140° to 150°E.	150° to 165°E.	165° to 180°E.	East of 180°E.	Total area
a_1A_1	a_1	-* (%)	27.7	35.6	69.5	-	40.2
	A_1	-	72.3	64.4	30.5	-	59.8
a_2A_2	a_2	11.9	16.5	19.9	28.9	0	17.0
	A_2	88.1	83.5	80.1	71.1	100.0	83.0
A'b'	A'	-	72.2	59.3	78.1	76.8	71.2
	b'	-	27.8	40.7	21.9	23.2	28.8
A''b''	A''	61.9	82.0	60.0	59.6	-	66.0
	b''	38.1	18.0	40.0	40.4	-	34.0

A''b'', but in the others no clear-cut basis for making the division could be discerned so the division was performed mechanically in the following manner. For A'b', when the length group at 101 to 104 cm. was taken at the center, a point at which the curve of the line changed was observed and this was taken as the boundary of the groups. The length group of 101 to 104 cm. was split into two parts, which were added respectively to A' and b'. In the case of a_1A_1 and a_2A_2, the length class standing midway between them was taken as the boundary and the length group at that boundary was divided into two, which were added respectively to the group of large fish and the group of smaller fish. According to the table, for all sea areas totaled, in a_1A_1 and a_2A_2 the proportion of a_1 and a_2 was less and the proportion of A_1 and A_2 was greater. In contrast to this, for A'b' and A''b'', A' and A'' were in greater proportion and b' and b'' in the lesser proportion. Comparing these results with those which were obtained for each sea area separately, the only example in which the two sets of results were in disagreement was at a_1A_1 for the area of 165°E. to 180°. In all other cases the relationships were found to be in agreement. To sum up, in general for a_1A_1 and a_2A_2 the proportion of the group of smaller fish was less and that of the group of larger fish was greater, whereas for A'b' and A''b'' the proportion of the group of smaller fish was larger and the proportion of the group of larger fish was smaller. Where one would think of linking these relationships directly to phenomena accompanying growth, this phenomenon is clearly incompatible. However, considered in the following manner it will be realized that the aforedescribed relationship is not necessarily contradictory. If we try comparing for separate years the relative manner in which the length groups appear which correspond respectively to a_1, a_2 and A_1, A_2, we can see throughout the data for the last 5 years that in both cases the former is small and the latter is large. From the point of view of age, the length groups corresponding to a_1 and a_2 are clearly younger than those corresponding to A_1 and A_2, and the fact that the modes for the younger groups of fish are always smaller than those of the older groups of fish can probably be ascribed to the problem of availability. Specifically, it is postulated that the main reasons are probably that the length groups corresponding to a_1 and a_2 come into the fishing ground in lesser volume or that they are subject to the operation of too low a catching efficiency because of the selectivity of the gear. It is not possible to offer a quantitative hypothesis in regard to what the degree of the effect of availability may be, but that it appears to be rather well marked can be assumed by analogy from the differences detected in the relative manner of appearance of length groups corresponding to a_1 and a_2 and A_1 and A_2, as seen in figure 4.

It is clear from the foregoing observations that the establishment of the assumption ($a_1A_1 \longrightarrow$ A'b', $a_2A_2 \longrightarrow$ A''b'') can be understood to involve no particular contradictions.

Concerning problem (b):

A difficulty lies in the fact that whereas A'b' and A''b'' are each composed of two different

groups, B_2 and B_3, which are assumed to be the result of the growth of the same fish, cannot be judged to be necessarily composed of two groups. In other words, the former are of the bimodal type while the latter are of the unimodal type. With regard to this point the following considerations may perhaps be brought forward.

First, looking at the form of B_2 and B_3, they can hardly be considered bilaterally symmetrical, for in each case they are skewed to the right. Furthermore, when we try comparing A'b' and A''b'', we see that in the former the displacements of A' and b' are small, while in the latter the displacements of A'' and b'' are large, and it is possible to point out an analogous relationship in the comparison between B_2 and B_3. That is, in B_2 the degree of skewness on the right is small whereas in B_3 it appears relatively large. The same sort of relationship can be indicated by making comparisons for each sea area separately (see fig. 1). Second, let us consider what changes in the course of their growth will affect two groups which differ in the time at which they were produced. When we examine the successive stages of existence of two groups defined in terms of length composition, it may be thought that perhaps with the passage of time they may tend more and more to overlap. It is thought that this is mainly due to the fact that with the passage of time there is a relatively greater increase in the growth rate differential as between the individuals than in the growth rate differential based on the difference in the time of production, and it is imagined that this effect also operates to some degree in problem (b).

If we think about the analogies pointed out under consideration 1, taking account of the effect of the process of growth as set forth under consideration 2, there is probably no obstacle to deciding that there is a fairly strong relatedness between A'b' and B_2 and A''b'' and B_3.

With regard to the assumptions ($B_2 \longrightarrow C'' \longrightarrow D_3$) and ($B_1 \longrightarrow C' \longrightarrow D_2$), no points of essential disagreement can be detected by a direct inspection of the form of the modes. It is thought that the fact that the modes gradually diminish in height is due to the effect of the increasing mortality and the problem of availability.

Figure 5 shows how the displacements of the modes look based on assumptions A, B, and C. As is clear from the figure, the growth rates based on these various assumptions are in very good agreement. This fact may be thought to strongly support the validity of assumptions A, B, and C.

As observed above, it must be said that there is a considerable rational basis for the establishment of assumptions A, B, and C, and consequently it can be judged that there is a strengthening of the validity of the hypothesis that the variations in modes from year to year arise from differences in the amount of reproduction or recruitment from year to year. However, there is still a gap between the establishment of the assumptions A, B, and C and the establishment of this hypothesis, so we shall make a further consideration of this point later.

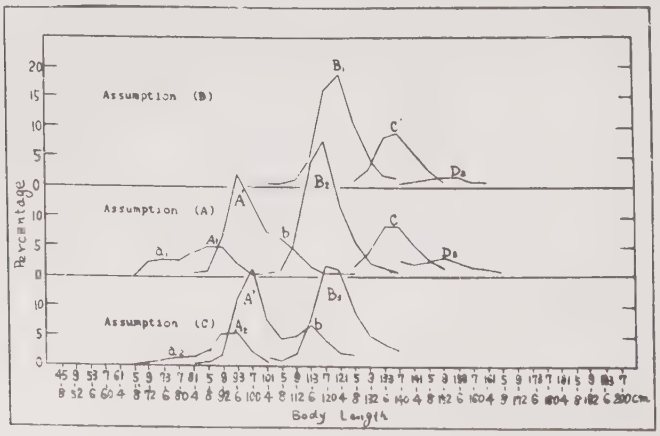


Figure 5.--Mode transformation based on assumptions A, B, and C.

Hypothesis 2 - Differences in the growth rate from year to year

This is a consideration of a case where ypothesis (2) is the controlling factor in the ariations in the modes from year to year. In his case: (a) the amount of growth during the ear assumed in hypothesis (1) should be taken the difference between years in the amount growth; (b) the differences in the amount of rowth between years are small by comparison ith the amount of growth within the year. hese two conditions are postulated in this case. e shall see whether or not it is possible to rm a rational postulate to account for the dis- acement of the modes accompanying growth hile satisfying the conditions of hypothesis (2) d conditions (a) and (b). If, on the basis of gure 4, we attempt to form an assumption for e sort of relationship that will satisfy condi- ons (a) and (b), the following relationships ay be thought of.

a_1A_1 (1948) ⟶ C' (1949) .... (D)

A'b' (1949) ⟶ D_2 (1950) .... (E)

a_2A_2 (1950) ⟶ C'' (1951) .... (F)

a''A'' (1951) ⟶ D_3 (1952) .... (G)

However, these assumptions are basically conflict on the following points. First, when e amount of growth within the year based on e assumptions is made to correspond to as- nptions A, B, and C, there exists in all ses between the amounts of growth of the two iscrepancy of approximately 3 : 1, and this lationship stands in opposition to the first position, which was that the rate of growth ies from year to year.

Secondly, when the amount of growth in the r based on this assumption and the discrep- cies among the length frequency groups ap- ring in the same year (which are handled as dependent units in the assumption) are made correspond with assumptions A, B, and C d are compared, there is in every case a screpancy between the two averaging 3 : 2. this sort of relationship is considered in di- ct connection with growth, it is thought to be early inconsistent.

In conclusion, assumptions (D) to (G) do t satisfy hypothesis (2), and it is also appar- t that the assumptions themselves do not sat- fy the relationship accompanying growth. In ort, as long as we postulate that schools of e same stock return repeatedly into the fishing grounds, we cannot establish any assumptions that would satisfy both hypothesis (2) and conditions (a) and (b) at the same time, and consequently it can be decided that hypothesis (2) cannot at least be the dominant factor in the variations in the modes from year to year.

Hypothesis 3 - Differences in migratory phenomena from year to year

Concretely, this hypothesis is based on the idea that the migrations of the schools as differentiated by length groups differ from year to year. What is meant in this case is that the schools which come into the fishing grounds in a given year and those which come into the fishing grounds in the following year do not have any direct relationship. However, it is anticipated that in order to link up hypothesis (3) rationally with the alternate-year cyclical phenomena already described, we must bring into hypothesis (3) in some form or another a cyclical migrational phenomenon which occurs in units of 2 years. Let us assume a displacement of the modes attendant upon growth based upon this sort of assumption, and examine the validity of the results. If we postulate the existence of migrational phenomena with a period of 2 years, the schools which come into the fishing grounds in a certain year may be thought to return again to the grounds 2 years later, so it is to be expected that any direct relationship will be between the schools in odd-numbered years and between those of even-numbered years and would not exist between those of successive years. Consequently we will assume the following relationships from figure 4.

Even-numbered years:

a_1A_1 (1948) ⟶ B_2 (1950) ⟶ D_3 (1952) .... (H)

B_1 (1948) ⟶ D_2 (1950) .... (I)

a_2A_2 (1950) ⟶ B_3 (1952) .... (J)

Odd-numbered years:

A'b' (1949) ⟶ C'' (1951) .... (K)

If we attempt to examine the validity of these assumptions as seen through the phenomena, it will be understood that as regards their relatedness from the point of view of the internal structure of the several length groups, it can be established under postulates similar to those considered for assumptions A, B, and C, while as far as growth rate is concerned there is general agreement among the several

assumptions and there is also agreement with the rate based on assumptions A, B, and C. Looking at the problem in this way, we can come up with the interpretation that assumptions A, B, and C and assumptions H, I, J, and K are analyses of the same phenomena from different starting points and that both are reasonable from their respective standpoints. As for the reality of assumptions A, B, and C and assumptions H, I, J, and K,

(1) Assumptions H, I, J, and K in comparison with assumptions A, B, and C apply to very particular cases, and in view of this fact and in the absence of other concrete facts supporting these assumptions, it may probably be concluded that their reality is very slight.

(2) As is clear from the considerations brought forth under (a) and (b), with regard to the establishment of the relationships ($a_1A_1 \longrightarrow A'b' \longrightarrow B_2$) and ($a_2A_2 \longrightarrow A''b'' \longrightarrow B_3$) for assumptions A and C, the reasonableness of these assumptions was positively promoted by the intervention of A'b' and A''b''. And it may be said that this fact shows a greater validity in assumptions A, B, and C, where the schools which appear respectively in even-numbered and odd-numbered years are considered directly, than in assumptions H, I, J, and K, where these schools are considered indirectly.

In conclusion, if for hypothesis (3) we postulate cyclical migratory phenomena with a 2-year period, it is possible that this can be the dominant factor in the fluctuations of the modes from year to year. However, if we consider the fact that assumptions A, B, and C, which are of a more general nature, also apply to the same identical phenomena, it is thought that it may be decided that in the present stage of studies this hypothesis has very little reality.

From the foregoing considerations, it has been shown that the applicability of hypothesis (1) is strengthened by assumptions A, B, and C, that hypothesis (2) can be judged to be at least not a controlling factor, and that there is room for the application of hypothesis (3) through postulating the existence of an alternate-year cycle in the migratory phenomena. No determination can be made under present conditions as to the problem of whether the elements which essentially control the phenomena are produced in accordance with hypothesis (1) or (2), or whether they arise from entirely different factors, or whether they are the effect produced by a complex intermingling of a number of factors, but in any case they must be said to be extremely interesting phenomena.

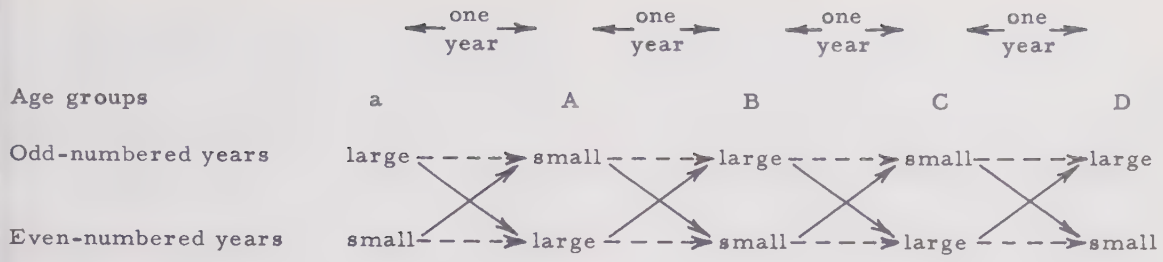
III. A Consideration of the Mechanism of the Alternate-year Cycle

We shall here attempt a consideration of the mechanism of the alternate-year cycle based on assumptions A, B, and C, which are thought to have the strongest reality. If we try to point out the most outstanding points of difference between the even-numbered years and the odd-numbered years as shown in the phenomena, in figure 3, (1) we can detect a tendency for the length group corresponding to a to be numerous in even-numbered years and scarce in odd-numbered years. However, its abundance in the even-numbered year 1952 differed hardly at all from that of odd-numbered years; (2) the length group corresponding to A appears as a conspicuously predominant mode in odd-numbered years but presents no such predominant mode in even-numbered years. A tendency can be seen for the position of this mode to be displaced to the left in even-numbered years and to the right in odd-numbered years; (3) the length group corresponding to B appears as a conspicuously predominant mode in even-numbered years, but in odd-numbered years it appears as an inconspicuous mode somewhat to the left in a position corresponding to b; (4) the length group corresponding to C appears as a mode only in odd-numbered years and in even-numbered years does not form any particular mode; (5) the length group corresponding to D appears as a very small mode only in even-numbered years and no mode appears for this group in odd-numbered years. In all cases the length groups larger than that corresponding to D show very unclear differences between odd and even years.

According to assumptions A, B, and C the length groups a, A, B, C, and D mentioned under (1) to (5) are assumed to be 1 year apart, so hereafter they will be handled as year classes a, A, B, C, and D. As is clear from (1) to (5), the factor contributing to the mechanism of the alternate-year cycle is principally the relative abundance as between years seen as separate ages, and at the same time it can probably be judged that this tendency is to be detected also in the displacement of the modes seen as separate ages.

(a) Concerning relative abundance:

The age groups that appear conspicuously in even-numbered years correspond to a, B,



nd D, while to those which appear onspicuously in odd-numbered years A and C orrespond. Consequently if we assume re-tionships attendant upon growth based on as-umptions A, B, and C, we can postulate the bove diagram of the mechanism.

In this diagram of the mechanism, the ords "large" and "small" indicate the rela-ve abundance of each age group as between e different years, the solid lines show the elationship accompanying growth, and the otted lines indicate the existence of the even-umbered year type and the odd-numbered year pe. As is clear from the figure, this mech-nism diagram satisfies the existence of the ternate-year cycle from the point of view of elative abundance, and it can be understood at the essential factors are marked variation very other year in the amount of the schools onsidered as separate age groups, and that the ge group a is taken as a starting point. Con-equently, if we think that D_1 which appears in 948 and D_2 which appears in 1950 have come rough the same process as D_3 appearing in 952, we can consider that the elements of the ternate-year cycle for 1948 and 1950 iginated 5 years before those years.

Concerning the displacements of the modes:

The only direct comparison which can be ade on this point is of age groups A and B, nd as already stated in (2) and (3), a tendency n be detected for the mode for age group A to e displaced to the left in even-numbered years nd to the right in odd-numbered years, and for ge group B contrariwise to the right in even-umbered years and to the left in odd-numbered ears (fig. 3). If we consider this to be direct-linked to the magnitude of the amount of fish these groups in the years referred to, it can e said that for both age groups A and B the ode is displaced to the right in years when sh are abundant and to the left in years when ey are scarce. However, considerable dis-repancies in the location of the modes can be etected among abundant years and among carce years, and we can also cite the example of age group A, which in 1949, when the fish were plentiful, and in 1952, when the fish were scarce, had its mode appear at almost the same position. Consequently, even though we assume that the displacement of the modes is a factor in the alternate-year cycle, it is obvious that it does not appear as such a clear-cut difference as did factor (a). At the present we cannot decide whether or not it is a factor in the alternate-year cycle, but it can be said that there is a possibility that it is, and in such case we may think that it is organically linked with factor (a) and we may expect that it will give important indications for a consideration of the mechanism giving rise to the alternate-year cycle.

IV. Considerations of the Mechanism by Which the Alternate-year Cycle Arises

In the preceding section it was shown clearly that a controlling factor in the alternate-year cycle is the marked difference in the amount of fish of different ages insofar as assumptions A, B, and C are used as a basis, and it was ascertained that it was possible to explain the mechanism rationally by relating it to the processes accompanying growth. We cannot say definitely whether or not the phenomenon of the alternate-year cycle will continue hereafter. But assuming that it will continue, we shall attempt to consider the mechanism which gives rise to it chiefly from the standpoint of pushing ahead these studies in the future.

From the diagram of this mechanism it is possible to interpret the source of the phenomenon as something which arose in age group a prior to its development. To put it concretely, we are dealing with the fact that the amount of fish in age group a is great in even-numbered years and small in odd-numbered years and that these phenomena are alternately repeated. Consequently, with regard to the mechanism giving rise to phenomena of this sort, it is thought that the following two ideas may be established:

(a) They arise as a result of gradual addition during the process of growth of age group a.

(b) They are determined at a definite time in some certain stage. It is impossible to carry out any consideration based directly on data with regard to (a), but it is thought that there is very little possibility of it unless it can be anticipated that the environmental conditions of this population may vary markedly from year to year during the course of growth of age group a. As for b, probably it is most correct to ascribe it to the problem of recruitment under hypothesis 1.

If we postulate the simplest possible case with regard to the problem of (b), we can assume two cases: (a) either the amount of spawning differs conspicuously every other year, or (b) even though the amount of spawning does not differ greatly there is a conspicuous difference every other year in the amount of attrition of the newly hatched or larval stages.

Before considering this problem we will first summarize what is known about the distribution and spawning habits of the bigeye.

1. Distribution:

According to Nakamura (1949, 1951), in the northern hemisphere in the Pacific Ocean the bigeye is distributed almost everywhere from 0° to 40°N. latitude, and it is further presumed to be broadly distributed in the southern hemisphere waters of the Pacific Ocean and in the Indian Ocean. According to recent records of operations of Japanese long-line vessels, the outstanding grounds where large catches of bigeye are made are first of all in the low latitudes, the main current area of the North Equatorial Current and the Equatorial Countercurrent, the aforementioned sea areas of the North Pacific, the Banda, and Flores seas, and the northeastern parts of the Indian Ocean. In the southern hemisphere waters of the Pacific Ocean at present the operating area is generally limited to N. of 20°S. latitude, but it has been ascertained that the bigeye is apparently rather densely distributed in the southern hemisphere also.

2. Spawning habits:

Nakamura (1949, 1951) has stated as common characteristics of the tunas and spearfishes that the spawning of these fishes takes place in broad areas of the low latitudes over long periods of time. From June to August of 1951 Kikawa (1953) observed in the area of 2°N. to 9°N. latitude, 161°E. to 174°E. longitude large numbers of bigeye having completely ripe, transparent eggs, which were thought to be close to spawning, and he has postulated that the spawning of the bigeye takes place in this sea area. The matters set forth below have not yet been formally reported, but they are the outline of what has become known as a result of the investigations of bigeye spawning at the Nankai Regional Fisheries Research Laboratory.

i) Spawning appears to be carried on principally in the main part of the North Equatorial Current or in the sea areas south of that current.

ii) The minimum size of maturity appears to be about 100 cm.

iii) The spawning season is very long and on the whole appears to extend almost throughout the year.

On the other hand, the results of the examination of gonads of bigeye taken from September to April in the sea areas of the North Pacific has revealed that they are all immature.

From the items given under 1 and 2 above we can deduce two things: that the North Pacific sea area is only a part of the total range of occurrence of the bigeye, and that the North Pacific sea area has no direct relationship to the bigeye spawning grounds, and consequently in the northern hemisphere waters of the Pacific Ocean there must be some direct mixing of the bigeye occurring in the high-latitude waters of the North Pacific and in the low-latitude sea areas through their spawning activity. Setting up these provisos, we will attempt to examine cases (a) and (b).

With regard to the case of (a), if we assume that the minimum size at maturity for bigeye is about 100 cm., it is clear that the age groups contributing to spawning must be at least 2 years or older. Consequently, insofar as no other special consitions exist, it may be thought highly unlikely that the amount of spawning will differ markedly every other year.

As for case (b), judging from the fact that the spawning of the bigeye takes place in low-latitude sea areas with stable environmental conditions and that the spawning is carried out over a long period of time, it may be thought highly unlikely that the rate of attrition will differ markedly every other year. Looking at the matter in this way, it is deduced that the mechanism which produces the alternate-year cycle is not something which appears in a simple form. If we assume that it does not arise in a simple form, it is thought that

problems of the following sort will have an extremely important significance judging from the pattern of distribution of the bigeye. This is the problem of in what form and to what extent the groups of bigeye in the North Pacific and the South Pacific and the Indian Ocean are connected through their spawning activity. If, as stated earlier, the principal spawning grounds of the group occurring in the northern hemisphere lie in the low-latitude sea areas, including the equatorial area, the principal spawning grounds of the groups occurring in the southern hemisphere waters of the Pacific and in the Indian Ocean will probably be of the same character as those for the northern hemisphere. In this case it may be thought that the spawning grounds of these three groups will at least in part overlap. If we start off from this idea, it will not be enough in dealing with the amount of recruitment to consider it a problem simply of the total amount, but it will be necessary to give consideration at the same time at least to the mechanism of replenishment in the northern hemisphere and southern hemisphere waters of the Pacific Ocean.

It is not possible at present to go any further into this problem than we have here. At any rate it is hard to believe that the problem of the alternate-year cycle is of such a character that it can be clarified by taking only the sea areas of the North Pacific into consideration. If we think of all the bigeye so broadly distributed throughout the Pacific and Indian Oceans as one great population, it is naturally to be anticipated to be in organic connection at various points with problems related to the internal organization of this mass, and it is thought that there is a necessity to push ahead the study of the problem from this standpoint. To express this in another way, it can also be said that for future studies the alternate-year cyclical phenomena have an important significance as a powerful means for the investigation of the structure of this population.

Summary

1. Length measurement data of bigeye taken in the North Pacific fishing grounds have been examined in various ways. Data were obtained for five periods extending from autumn to winter of the years 1948 to 1953.

2. As a result of comparisons of the length composition in the different sea areas,

   a. It has been observed that the positions at which the modes appear are as a rule in agreement for different sea areas in the same year.

   b. Although the relative heights of the individual modes differ conspicuously from sea area to sea area, as a characteristic which extends to all the years, in the more westerly sea areas the modes formed by the smaller size groups are predominant while in the easterly sea areas the modes formed by the larger size groups predominate. In other words, in the more westerly areas the groups of smaller fish are more abundant, while in the easterly areas the groups of larger fish are more abundant.

   Judging from (a) and (b) it is thought that there is very little possibility that the composition of the groups which come into the fishing grounds results from two or more clearly different racial stocks.

   c. There are conspicuous discrepancies from year to year, particularly in the positions of the modes and in their height, indicating alternate-year cyclical phenomena.

3. With regard to the causes of the annual displacements of the modes we have considered the validity of three hypotheses earlier advanced by Nakamura, Kamimura, and Yabuta (1953):

   (1) Variation from year to year in the amount of recruitment

   (2) Variation from year to year in the growth rate

   (3) Variation from year to year in the migrational phenomena

   As a result, with regard to hypothesis (1), we concluded that its validity is strengthened by the fact that the assumptions A, B, and C that have been made in relation to the processes accompanying growth have a rather fairly rational basis. As for hypothesis (2), since it is difficult to get a rational grasp of the phenomena insofar as this hypothesis is used as a basis, it has been decided that it cannot at least be the controlling factor. In the case of hypothesis (3), it has been shown that there is room to apply it by postulating migratory phenomena on an alternate-year cycle.

4. The mechanism of alternate-year cycles has been examined on the basis of assumptions A, B, and C, which had been thought to have the strongest validity. As a result it has been shown that the majority of the elements forming this mechanism lie in the fact that there is a marked variation every other year in the amount of the schools regarded as age groups, and it also has been pointed out that there is a possibility that the displacements of the modes regarded as age groups are contributory to this mechanism.

5. Based in the same way on assumptions A, B, and C and chiefly from the point of view of the carrying on of future studies, we have considered the time of appearance of the alternate-year cycle and the mechanism which gives rise to it. It has thereby been made clear that the time is anterior to the development of age group a, but it has not been possible to show whether (a) it arises gradually in the course of the process of growth, or (b) whether it is determined at once at one particular stage. However, in a general manner of thinking it should be said that (b) has the greater possibility, and it is also thought correct to ascribe the time to the early stages of life. This is also in agreement with hypothesis (1). Even though we assume that the matter is decided at once in the early stages of life, it is hard to think that the mechanism arises in a simple form, and in handling the matter of recruitment it is thought that there is a necessity for considering the problem of the mechanism for replenishment in at least the North Pacific, South Pacific, and Indian oceans.

6. It cannot be determined whether or not alternate-year cyclical phenomena will continue hereafter, but assuming that they do continue, it is anticipated that in further developing future bigeye studies these phenomena will provide an important starting point and a key to the consideration of various matters.

Bigeye Studies. II. A Consideration of the Size Composition of Bigeye Taken on Pole and Line*

By

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/English title and summary/

Biology of the Big-Eyed Tuna, Parathunnus mebachi (Kishinouye) - II. A Consideration on the Size Composition of the Big-Eyed Tuna Caught by Pole and Line

The present paper deals with analysis of length frequency of the young big-eyed tuna caught by pole and line. Especially a relationship between the fishing localities and the discrepancy in the mean length which was evident in the same modal group has been discussed.

1. Data used for the study are the measurement of body length obtained from numbers of samples and the pertaining information furnished by fishing boats at two ports during the period from June to July 1953.

2. In the length frequency two dominant modes, A and B, were recognized not only throughout the samples (Fig. 2) but also in the mean value of each school from 1 to 17 examined nearly in the same period. These findings have led the writers to an assumption that modal group A may form an independent unit different from group B in regard with length frequency.

3. As no uniformity in the length frequency has been found among the samples belonging to the same group (Table 1), correlation between the mean length of the groups and fishing locality has been examined, substituting the size composition sorted by fishing cruise for that by school of fish, because few data on the latter were available for this purpose.

As a result it was found that the mean length of the fish in both groups A and B was small in the western area of the fishing grounds and tends to become greater as one goes east (Table 2, Fig. 3).

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4. The fact that the survey period fell on the months of June to July when the fish would be migrating northward (Fig. 3) seems to suggest that the easterly increase in the mean length may be attributable to different tendencies of the migrating behavior between the fish in the eastern area and those in the west. In other words, the fish of both groups A and B in the eastern area are supposed generally larger in size than those of the corresponding groups in the west, while all migrating northward.

/end of English summary/

It has been known in the past that in the tuna pole-and-line fishery some young bigeye tuna[1] are taken incidental to the capture of skipjack, albacore, and small yellowfin, but up to the present time there have been no detailed reports concerning them. In general the fishes on which the pole-and-line fishery operates have a strongly schooling character, and this character is clearly evident in the young bigeye. In taking up problems related to the structure of the population, with fishes of a strong schooling character, it is thought that the weight given the schools, which are the structural units of the populations, is of very great significance. In the present study the size composition of the separate schools is considered from this point of view, note is taken of the discrepancies among schools appearing in the results, and some consideration is given to linking these discrepancies with the provenance of the schools.

The data are mainly fish measurements and information on fishing conditions collected at the Yaizu fish market in June and July 1953.[2] Some data collected at the Makurazaki fish market are also included; they were supplied by the Oceanic Resources Section of the Tohoku Regional Fisheries Research Laboratory.

Appreciation is here expressed to Director Hiroshi Nakamura of the Nankai Laboratory and to Dr. Yabe, Chief of its High-seas Resources Section, for their advice in connection with this study, and also to the Oceanic Resources Section of the Tohoku Laboratory for its unfailing cooperation and for the valuable data supplied.

Size Composition by Separate Schools

In panels 1 to 17 of figure 1 we have taken those samples which, on the basis of the fishermen's reports, were judged to have clearly been caught from a single school, have chosen only those from which 30 or more fish were measured, and have arranged them in order of average size; the bottom panel shows the average composition of 1 to 17. Figure 2 is a comparison of the average composition of the schools represented in figure 1 (panel a) and of the composition based on all of the measurements taken during approximately the same period (b).

As is clear from figure 2, the positions of the modes in the size compositions represented by (a) and (b) are in very good agreement, and in both of them the presence of two modes, A and B, is clearly apparent. In addition, in the average size composition represented in panel (a) there is a faintly discernible mode C centered at 100.1 - 102.0 cm., but in the composition based on all the fish measured, represented in panel (b), this mode is not clear. As there are very few data on the group making up mode C, it is omitted from further consideration. For convenience in discussion, the groups making up modes A and B will be referred to hereafter as groups A and B.

The presence of groups A and B can also be pointed out in the several schools represented in figure 1. For example, schools 4, 14, and 17 can be cited as having a simple composition, and each of them is composed either of group A or of group B. In the other schools[3], also, modes appear at locations corresponding to A and B, and we do not, at any rate, see anything that would positively deny the presence of modes A and B. As has been indicated above, groups A and B are interpreted as forming individual units[4] even when they are in different schools,

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1/ These small bigeye are generally called bachimeji or daruma, whereas the adults are called mebachi.

2/ The length used was the so-called "fork length", measured from the tip of the snout to the deepest part of the fork of the caudal fin.

3/ If we look at the relation of mixed schools to the objects with which they were associated (see notes to fig. 1), we find that they were all with whales, sharks, drift logs, etc. Taking this point into consideration, it may be wondered whether the intervention of such objects of association may not play a significant role in the formation of mixed schools.

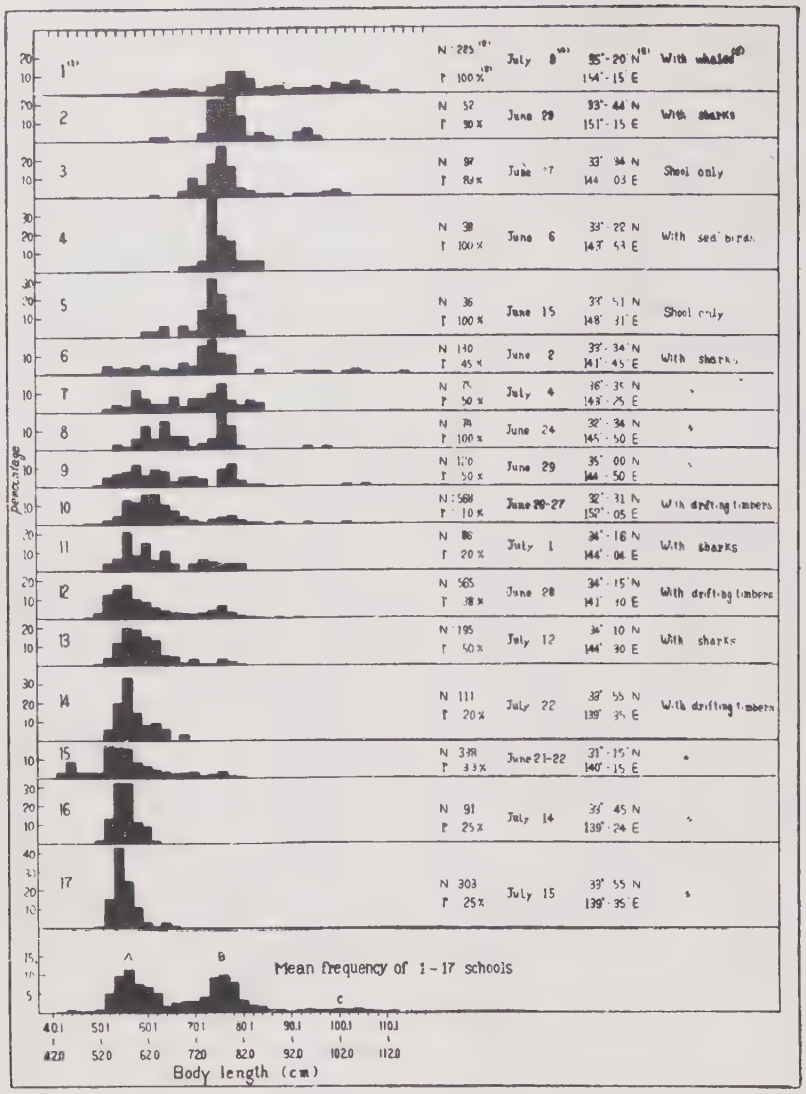

Figure 1.--Length frequency by school. (1): Sample number
(2): Size of sample (3): Sampling fraction
(4): Date of catch (5): Locality of catch
(6): Kinds of associates sighted with the fish.

and it is hypothesized that they are length groups which differ with respect to their early life history.

A point which requires attention here is the fact that for both group A and group B the locations at which the respective modes appear differ slightly from one school to another. This sort of discrepancy is thought to appear more conspicuously in group A than in group B.

Table 1 is a statistical examination of the separate samples, for both group A and group B, in order to see whether or not they were after all homogeneous. For this examination the determination of the size ranges of the two groups was based on the size composition of all measurements (fig. 2, panel b) and they were taken to be 50.1 - 68.0 cm. and 70.1 - 86.0 cm. respectively. For each group only those

4/ The question of whether or not the two are different age groups will be examined in a subsequent report.

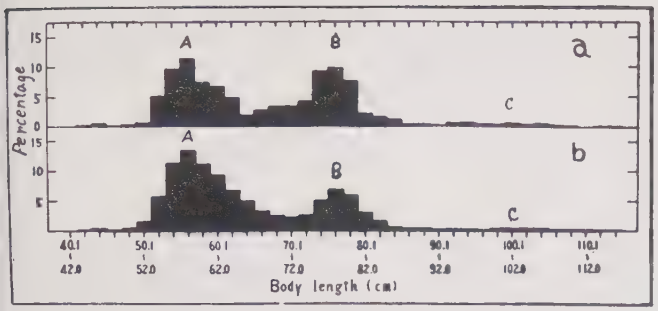

Figure 2.--Comparison of length frequency. Upper (a): Mean frequency of the schools 1-17 shown in Fig. 1. Lower (b): Frequency of the total individuals measured during the same period as the samples of the schools 1-17.

Table 1.--The tests of variance and difference between mean value of body length (5% level)

GROUP A (50.1 - 68.0 cm.)

Sample No.*	Size of sample	Mean	Mean square	No.	1	2	3	4	5	6	7	8	9	10
1	23	63.7	8.6	1										
6	36	58.7	23.6	2	X									
7	32	61.1	17.0	3	X	O								
9	70	59.7	16.7	4	X	O	O							
11	65	59.6	16.5	5	X	O	O	O						
13	177	59.3	13.3	6	□	X	□	O	O					
14	107	58.0	10.1	7	□	X	X	X	X	X				
15	245	56.9	15.5	8	X	X	□	□	□	□	X			
16	90	56.4	5.8	9	□	X	X	X	X	X	X	X		
17	303	56.2	7.6	10	□	X	X	X	X	X	X	X	X	

GROUP B (70.1 - 86.0 cm.)

Sample No.*	Size of sample	Mean	Mean square	No.	1	2	3	4	5	6	7	8	9	10
1	100	79.5	10.6	1										
2	43	77.7	8.5	2	□									
3	82	76.4	9.7	3	□	□								
4	37	76.8	10.4	4	□	O	O							
5	30	75.8	5.1	5	X	□	X	X						
6	77	75.7	7.2	6	X	□	O	□	O					
7	41	77.0	16.8	7	X	X	X	O	X	X				
9	42	77.0	12.2	8	□	O	O	O	X	X	O			
11	21	75.7	10.8	9	□	□	O	O	X	O	O	O		
15	30	74.7	8.6	10	□	□	□	□	O	O	X	□	O	

X: Significant in variance.

□: Not significant in variance, but significant in difference between mean.

O: Not significant both in variance and in difference between mean.

*: The sample numbers correspond to those of the schools of Fig. 1 respectively.

samples with 20 or more measurements were used.

As is clear from the table, out of 45 comparisons, A has 28 and B has 13 in which the variance shows significant differences; A has 9 cases out of 17 and B has 15 out of 32 in which the difference in variance is not significant but the difference between the means is significant and A has 8 cases and B has 17 in which neither the variance nor the mean differ significantly. These facts show, for both group A and group B, that the samples from individual schools have no common size composition, and therefore in neither group can they all be regarded, on the basis of probability, as samples drawn from the same universe.

Kawasaki (1952), discussing the populations of skipjack migrating into the Northeastern Sea Area, has reported that the size compositions of individual schools separated by age cannot be considered on the basis of probability as samples from a single population. This agrees with the above-described results obtained with bigeye.

Various reasons for the lack of uniformity among the schools, such as the influence of biological characteristics and environment, sampling error, and so forth, can be thought of, but account must also be taken of the possibility that one reason may be a lack of uniformity within the population[5/]. If this is the case, it is believed that the lack of uniformity seen among the schools will provide an important clue for deducing the lack of uniformity of the population.

Relation of Nonuniformity of Composition to Locality

In table 2, for the size compositions of the landings of individual vessels the average lengths of groups A and B have been found and their relation to longitude has been shown. A classification by cruise has been used because there were few data available which were recorded by separate schools and the separation by cruise was thought to provide the best approximation. Since the problem here is the local character of the size composition, we have used only data from vessels which operated within areas of 4 degrees of longitude and 2 degrees of latitude. The vessels which operated over more than 2 degrees of longitude were assigned to the area in which the majority of their fish were taken. Furthermore, since the average length of the fish in samples varies widely depending on the amount of data available, only those samples in which 20 or more fish in each group were measured were used.

Of course, the size composition of the catch of an individual vessel is thought to represent the averaged values of the composition of several schools, but it is assumed that in its trend it will reflect the peculiarities of the individual schools in the area in question. It can be clearly seen from the table that for both group A and group B the average length of the fish is smaller in the more western areas and that it tends to increase to the eastward.[6/] By comparing, in the lower parts of both tables, the frequency by longitude and by 10-day periods, it is clearly shown that the above-mentioned slope downward from east to west is not due to a difference in growth arising from any lag in the time of capture.[7/]

In figure 3 the distribution of average lengths has been indicated, as explained in the legend, by plotting the positions of capture with symbols corresponding to three categories. By referring to the plot, the downward slope from east to west indicated in table 2 can be noted at different latitudes.

Figure 4 presents the size composition of the bigeye measured at the Makurazaki fish market.

Since very few data classified by individual vessels were available, the data from a number of vessels were combined for presentation. The locations of the catches in both June and July were west of 130°E., and when they are compared with the fish measured at the Yaizu market during the same period of time, it can clearly be seen that the fish were captured in more westerly areas (see fig. 3). As for the size composition, all of the modes appearing in

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[5/] In this case the "population" indicates the schools migrating into the fishing grounds considered separately by groups.

[6/] For group A $r = 0.73$, for group B $r = 0.56$. In both cases the probability that these values could be obtained from a universe in which $r = 0$ is $P < 0.005$.

[7/] For group A $r = 0.11$, for group B $r = -0.13$. In both cases the probability that these values could be obtained from a universe in which $r = 0$ is $0.50 > P > 0.25$.

Table 2.--Number of the samples correlated between longitude, mean length, and date of fishing

Upper: Longitude and mean length of catch by fishing cruise

Lower: Longitude and date of fishing.

GROUP A

	°Longitude (E.)	134 to 136	136 to 138	138 to 140	140 to 142	142 to 144	144 to 146	146 to 148	148 to 150	150 to 152	152 to 154	154 to 156	156 to 158	158 to 160
Mean length (cm.)	53.1 - 54.0													
	54.1 - 55.0	1												
	55.1 - 56.0	1		1										
	56.1 - 57.0			2	1									
	57.1 - 58.0			2	1	4	1							
	58.1 - 59.0				1	6	3	1						
	59.1 - 60.0			1	1	2	4	4	1	1	1			
	60.1 - 61.0					2		3	1		1			
	61.1 - 62.0					1								
	62.1 - 63.0						1							1
	63.1 - 64.0											1		
	64.1 - 65.0													
Date of fishing	June, First decade			2	1									
	Second "			1										
	Last "				2	2	4		1	1	1			
	July, First "				1	6	1	8	1		1	1		1
	Second "			2		7	2							
	Last "	2		1			2							

GROUP B

	°Longitude (E.)	134 to 136	136 to 138	138 to 140	140 to 142	142 to 144	144 to 146	146 to 148	148 to 150	150 to 152	152 to 154	154 to 156	156 to 158	158 to 160
Mean length (cm.)	73.1 - 74.0													
	74.1 - 75.0			1	1	1								
	75.1 - 76.0				2	1	1		1					
	76.1 - 77.0				2	6	4	1	1					
	77.1 - 78.0					4		5	3	1	1			1
	78.1 - 79.0						1							
	79.1 - 80.0					1						1		
Date of fishing	June, First decade				2	4	1							
	Second "			1					4					
	Last "				2	1	4		1	2	1			
	July, First "				1	5	1	6	1			1		2
	Second "					3								
	Last "													

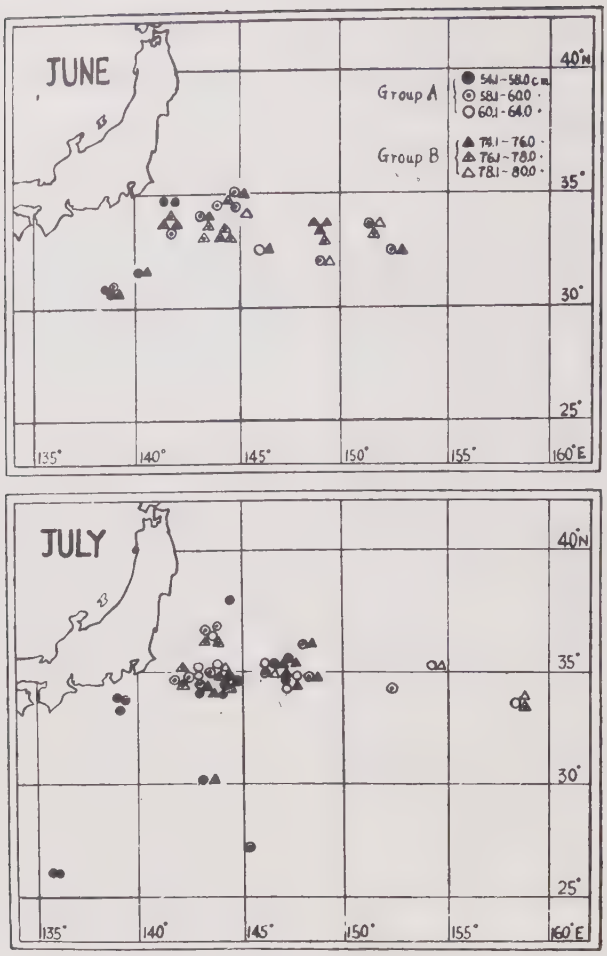

Figure 3.--Distribution of mean length by group and cruise.

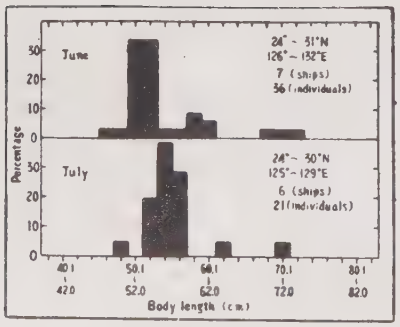

Figure 4.--Length frequency of the samples measured at the Makurazaki fish market.

both June and July correspond to group A; if we try to compare them with the composition of group B, as shown in figure 2, we see that their positions are notably displaced to the left.

A Consideration of the Gradient and the Source of Migration

For a close relationship between nonuniformity of the population and locality, such as was discussed in the preceding section, the usual mechanism that would come to mind would probably be to relate it to the source of the migrations of the schools. As can be seen in figure 3, in June and July the schools clearly show a northward movement. It is thought that these schools probably continue to move north through the spring and summer, so it is assumed that in June and July they are engaged in this northward movement. As they proceed

north, the schools in the western areas are thought to be forced by the configuration of the Japanese coast to move gradually eastward with a resultant intensification of their contacts with the schools moving northward in the more easterly areas that would greatly promote the mingling of the two. It is deduced that the internal structure of the population in June and July corresponds to just this stage. Consequently, if the fact that within the same group the proportion of small fish is greater in the more westerly areas, with the proportion of large fish increasing to the eastward, is taken to originate from a difference in the source of the migrations of the schools moving north in the westerly areas and those moving north in the easterly areas, then it is deduced that even though both may be in a stage where their mingling is being brought about, the mingling is not yet complete.

In the first report of this series the authors studied the annual changes in the size composition of the bigeye tuna taken on longlines in the North Pacific area, and in that report too, as the result of a comparison of the size compositions in different localities, it was pointed out that the same sort of phenomenon could be seen in the case of the longline-caught fish. Whether this phenomenon common to the fish in the catches of both fisheries arises through exactly the same mechanism in both cases can neither be affirmed or denied, but the probable presence of a close relationship is hypothesized. If the hypothesis set forth above in regard to the relationship between the east-west gradient and the source of migration were correct, it would be noteworthy as an example of the migratory pattern and mixing process of the bigeye tuna in the North Pacific.

Albacore Studies. III. Size Compositions Seen in the Several Ocean Currents*

By

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/English title and summary/

Studies on the Albacore - III. Size Compositions Classified by Ocean Current

The size compositions of albacore distributing in various current areas of the Pacific have been examined. The following have been found with the fish caught in the Western North Pacific areas.

1) The albacore occurring in the North Pacific Current area seem to be remarkably different from those in the North Equatorial Current and in the Equatorial Countercurrent areas in size composition. A greater majority of the fish distributing in the North Pacific Current area consisted of the ones less than 100 cm. in body length. They are supposed to belong to a group of immature fish. However, most of those caught in the areas of the North Equatorial Current and the Equatorial Countercurrent measured more than 90 cm. in length and likely belonged to a mature group (figs. 1 and 2).

2) There is a discrepancy of about 10 cm. between the modal length of albacore caught in the North Equatorial Current and that of the fish in the Equatorial Countercurrent. This phenomenon may have a close relation with the sex ratio of the fish (fig. 2 and table 2).

3) Variance in the size compositions between albacores in the North Pacific Current area and in the other current areas is more conspicuous then the regional difference and seasonal one within the North Pacific Current area (table 3).

The above evidences are indicative of the fact that each of the various ocean currents would present an environment considerably different from the others for tunas, as has been pointed out by Nakamura (1954).

/end of English summary/

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The author has earlier pointed out that the size composition of albacore in the area of the North Pacific Current presents regional (Suda 1954b) and seasonal (Suda 1955) variations. It has frequently been pointed out that different ocean currents represent different environments for the tunas, and that if the current differs, the ecological significance of the tunas distributed there also comes to differ (Nakamura 1949, 1954; Nakamura, Yabuta, and Ueyanagi 1953). From this point of view, the manner in which the size composition of the albacore distributed in the North Pacific Current differs from those of albacore in other current areas--in this case the North Equatorial Current and the Equatorial Countercurrent--is a matter of extraordinary interest.

(1) Sizes of Albacore Distributed in the North Pacific Current, the North Equatorial Current, and the Equatorial Countercurrent

The size compositions for these three current areas are summarized in figure 1. (The fishing method in all cases is the longline.) The size compositions for the North Equatorial Current and the Equatorial Countercurrent differ conspicuously from that for the area of the North Pacific Current (Suda 1954a, 1955). Almost the whole is composed of fish of 90-120 cm., that is the largest sizes attained by albacore. This is markedly different from the albacore of the North Pacific Current area, where the greater part is medium and small fish (under 90 cm.). Consequently the range of the size composition is notably narrow as compared with that found for the North Pacific Current. From the opposite point of view, this can be regarded as an outstanding point shared in common by the albacore of the North Equatorial Current and those of the Equatorial Countercurrent. However, a difference can still be detected between the albacore of the North Equatorial Current and those of the Equatorial Countercurrent, and that is that there is a discrepancy of about 10 cm. in the modal length between the albacore of the two areas. For the albacore of the North Equatorial Current, fish about 110 cm. long are the principal group, while in the area of the Equatorial Countercurrent the principal group is at about 100 cm., which means that the fish in the North Equatorial Current are larger.

Figure 2 shows the size compositions of the albacore distributed in the three current areas schematically using the average values of data obtained in the years 1948-1952. The symbol a represents the period of southward movement in the North Pacific Current (longline fishery), b the period of northward movement in the same area (pole-and-line fishery), c the North Equatorial Current (longline), and d the Equatorial Countercurrent (longline). The size groups are numbered as in Suda (1954a), and the shaded portion represents the size group which the author has treated as the group of fish of advanced age (Suda 1954a). The lower root of the latter is in approximate coincidence with what Ueyanagi (1954a) has hypothesized as

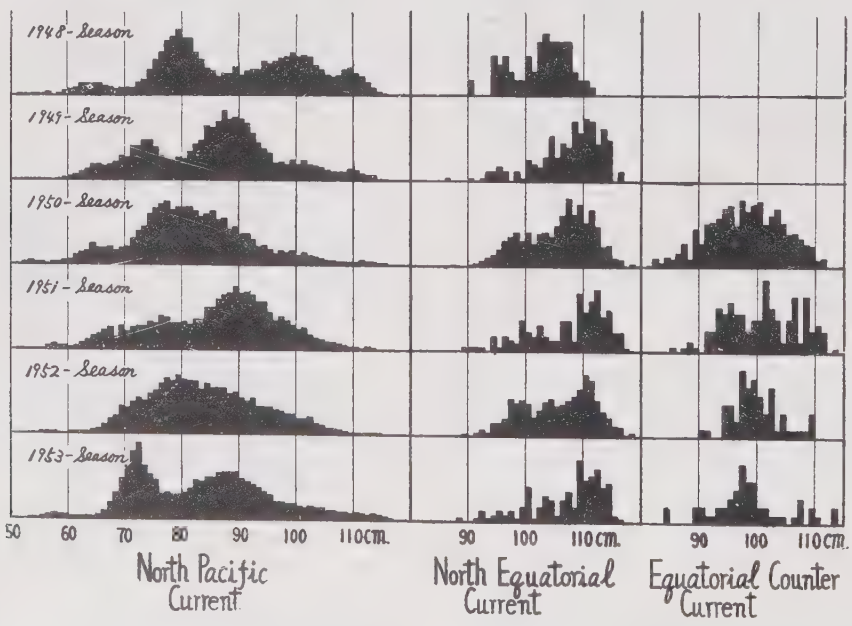

Figure 1.--Size composition classified by the current.

Table 1.--Number of fish measured

Area \ Season	1948	1949	1950	1951	1952	1953
North Pacific Current area	15,801	18,516	15,131	16,777	40,489	35,635
North Equatorial Current area	91	190	1,204	151	530	143
Equatorial Countercurrent area	-	-	530	138	58	52

the smallest size participating in spawning. In a rough approximation the following relationship can be postulated for the size compositions shown in a - d.

a - b ≒ advanced age group ≒ c + d

This is thought to mean that (1) on appearances, at least, the distribution of medium and small albacore is limited to the area of the North Pacific Current, or in other words to the north side of the Subtropical Convergence (the boundary between the North Pacific Current and the North Equatorial Current). (2) The albacore schools distributed south of the Subtropical Convergence are all made up of mature individuals. (Ueyanagi (1954b) considers the albacore distributed in the North Equatorial Current, at least, to be related to spawning.) (3) At the season of the changeover from a to b, that is, the time when the albacore in the North Pacific Current shift from a southward to a northward movement, the advanced age group is recruited from the North Pacific Current area into the waters south of the Subtropical Convergence*. Consequently, we have on the north side of the Convergence, that is, in the North Pacific Current area, an immature group, and on the south side of the Convergence, that is, in the North Equatorial Current and the Countercurrent, a mature group which has come over from the north side, and this indicates a remarkable ecological difference between the albacore on either side of the Convergence. It is thought that the discrepancy between the length distributions shown in c and d may be due to the marked difference in the sex ratios of the albacore in the two current areas. Figure 3 gives the length frequencies separately by sexes for the albacore taken in the

*The shift in fishing method from longline to pole and line can also be thought of as a cause of this, however, it is actually possible to trace the group which crosses the Subtropical Convergence to the southward.

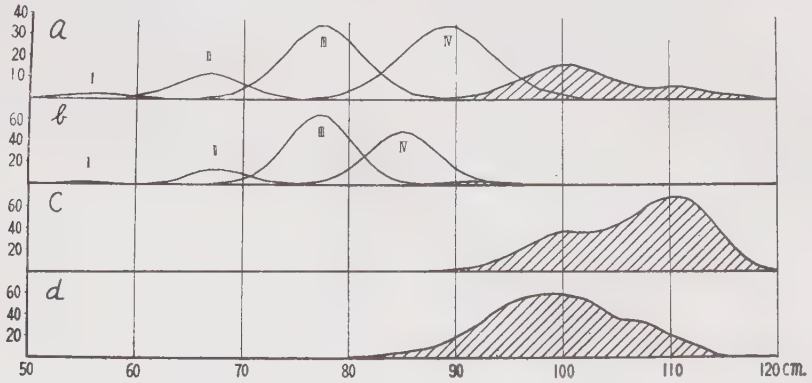

Fig. 2.--Average size composition in each current area. Ordinate represents the permillage.

a: North Pacific Current area (southward migrating season).
b: North Pacific Current area (northward migrating season).
c: North Equatorial Current area.
d: Equatorial Countercurrent area.

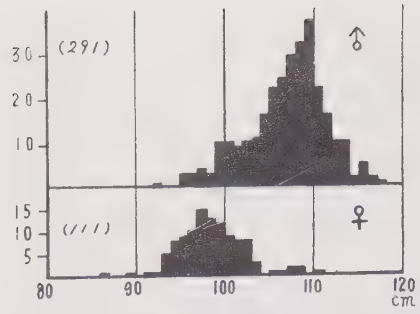

Figure 3.--Length frequency of males and females caught in the North Equatorial Current area.

North Equatorial Current area. The length distribution of the males very closely resembles that for the North Equatorial Current, and that for the females just as closely resembles the size composition for the Equatorial Countercurrent. Since we have no data with sex determinations for the albacore of the Countercurrent area, we cannot immediately conclude that the discrepancy between the sizes in c and d is due to a difference in sex ratios, but at any rate it is certain that there is an extraordinarily high proportion of males in the North Equatorial Current area (table 2). On the other hand, we cannot rule out the possible influence of the albacore of the Southern Hemisphere, so there is a need for further investigation in this field.

(2) Size Differences Within Currents and Size Differences Between Different Currents

The internal differences in size composition seen within a current area are, as has already been pointed out, regional and seasonal. Within the North Pacific Current area there is a marked tendency for the size of albacore taken along the same latitude to increase gradually from west to east (Suda 1954b). This change in the size composition in an east-west direction is not uniform, being extremely gradual in some cases and rather abrupt in others. For example, the change seen in the vicinity of 150°E. is conspicuous. Such regional variations can be regarded as corresponding to internal changes in the character of the North Pacific Current.** It has already been remarked that the seasonal variations*** are thought to rest largely on ecological causes.

Table 3 has been compiled in order to compare the degree of difference between size compositions within currents with that between currents. This table shows the discrepancies between the size group composition for each area (the length frequencies analyzed by normal distributions into 5 groups (Suda 1954a)) and the average size group composition for the North Pacific Current. The reason for using the average values for this area as the base for comparison is that this is the area for which

**For example, east of 150°E. the North Pacific Current flows almost regularly eastward, but west of that longitude is the place where the Kuroshio turns the direction of its flow from northeast to east, and there are many irregular currents.

***Since it is the prevailing rule all over the area of the North Pacific Current that the size of the fish gradually increases from west to east, there is thought to be little possibility of the existence of different stocks (Uda and Tokunaga 1937).

Table 2.--Sex ratio of albacore* in the North Equatorial Current area

Date of investigation	Locality		Male	Female	Ratio (♂/♀)
May 4 -May 23, 1949	18°18'N.-20°59'N.	148°10'E.-152°02'E.	84	40	2.1
June 22 -July 2, 1949	21°56'N.-22°56'N.	148°52'E.-152°54'E.	59	26	2.3
Mar. 5 -Mar. 22, 1949	21°00'N.-24°13'N.	143°32'E.-151°45'E.	14	6	2.3
Feb. 14-Feb. 19, 1950	22°12'N.-24°42'N.	149°52'E.-152°28'E.	17	3	5.7
Mar. 26-Apr. 6, 1950	22°50'N.-24°10'N.	143°15'E.-146°09'E.	56	9	6.2
May 17 -June 14, 1952	13°55'N.-22°54'N.	146°23'E.-153°06'E.	10	12	0.8
July 2 -Aug. 1, 1952	10°08'N.-24°04'N.	150°23'E.-158°43'E.	56	16	3.5
	Total		296	112	2.64

*Includes the individuals whose body length was not measured.

Table 3.--Dissimilarity of size component by locality. As the standard of the comparison, the mean value of four localities in the North Pacific Current area was used

Area	Season	140°E.-150°E.	150°E.-160°E.	160°E.-170°E.	170°E.-180°E.
orth Pacific Current rea	1948	O	□	□	O
	1949	X	□	□	□
	1950	□	□	□	□
	1951	O	□	□	□
	1952	O	□	□	O
	1948	—		Northward migrating albacore (caught by pole and line)	
	1949	—			
	1950	—			
	1951	O			
	1952	□			
orth Equatorial urrent area	1948	X	X	—	—
	1949	X	X	X	—
	1950	X	X	X	X
	1951	X	—	X	X
	1952	X	—	X	X
quatorial Counter- urrent area	1948	—	—	—	—
	1949	—	—	—	—
	1950	X	X	X	—
	1951	X	X	X	—
	1952	X	X	—	X

e have the most data and we can see the ternal changes in the size composition more early than in other current areas. The discrepancies were shown in the following manner. r each current we found $\sum_{n=1}^{5} \frac{(m_n - M_n)^2}{M_n}$, d where this value was less than 50 we rked it □, when 50-100 O, and when over 0 X. M_n is the percentage of Group n in e average size group composition for the rth Pacific Current, and m_n is the percentge of Group n for each of the localities. On basis of table 3 it can be said that (1) the fferences in the size composition as between fferent currents is far more conspicuous an the regional differences within the North acific Current, and (2) the differences beween currents are also more outstanding than e seasonal differences in the size composion within the North Pacific Current. onsequently, for the North Pacific Current, least, the differences from other currents re much greater than the variations within e current.

Conclusions

(1) The albacore of the North Pacific urrent, the North Equatorial Current, and the Equatorial Countercurrent have differing size compositions (fig. 1).

(2) The differences in size composition between the North Pacific Current and the other two currents are much greater than the various kinds of internal differences seen within the North Pacific Current (table 3).

(3) It is thought that there is a connection between such differences in size composition and the fact that the possibilities of spawning and the sex ratios differ as between currents.

The foregoing facts clearly confirm what Nakamura (1954) has indicated about different currents being different biological environments (conclusion 2) and the differences in the ecological significance of the schools which are distributed in different currents (conclusion 3).

In conclusion the author wishes to thank those members of the staff of the Nankai Regional Fisheries Research Laboratory who collected the data, and also Director Nakamura and High Seas Resources Section Chief Yabe for their assistance.

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NAS AND TUNA FISHERIES OF THE WORLD
AN ANNOTATED BIBLIOGRAPHY, 1930-53

BY WILVAN G. VAN CAMPEN AND EARL E. HOVEN

FISHERY BULLETIN 111
From Fishery Bulletin of the Fish and Wildlife Service
VOLUME 57

UNITED STATES DEPARTMENT OF THE INTERIOR, Fred A. Seaton, *Secretary*
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ABSTRACT

This bibliography attempts to list, with descriptive annotations and a subject index, important literature published between 1930 and 1953 dealing with the tunas and their fisheries in all parts of the world. It is thus a continuation of Corwin's (1930) work, which extended with similar scope through 1929, and an extension of Shimada's (1951), which was limited to the biology of Pacific tunas. The tunas with which it deals are those fishes customarily so-called in commercial parlance and usually classified in the genera *Thunnus, Neothunnus, Parathunnus, Germo, Katsuwonus, Euthynnus,* and *Auxis* and their various synonyms. All aspects of the biology of the tunas are dealt with, as are descriptions and histories of all types of tuna fisheries, commercial and exploratory tuna fishing methods and results, fishing gear, catch statistics, and fishery management, but processing technology, economics and marketing, folklore, and purely literary references have been excluded.

UNAS AND TUNA FISHERIES OF THE WORLD: AN ANNOTATED BIBLIOGRAPHY, 1930-53

By Wilvan G. Van Campen, *Translator*, and Earl E. Hoven, *Librarian*,
Pacific Oceanic Fishery Investigations

is bibliography is an expansion and continua- of that compiled by Shimada (1951) for the gy of the Pacific tunas. It covers the period the publication of the tuna bibliography of in (1930) to 1953, inclusive, and its geogra- l scope is world-wide. It incorporates all of ada's material except that which antedates

e subject matter of the bibliography comprises spects of the biology of the tunas as well as una fisheries, fishing methods and gear, fish- statistics, laws, and regulations. The subject following the bibliography provides a de- l outline of its content. Papers dealing sively with processing technology, fishery nics and marketing, and material of purely ry or folkloric interest have been excluded.

e compilers have considered as tunas most of combroid fishes ordinarily so-called: the alba- (*Germo*), the bluefin (*Thunnus thynnus*) or tuna (*T. orientalis*), the yellowfin (*Neothun-* the oceanic skipjack or striped tuna (*Katsu-s*), the bigeye and blackfin tunas (*Parathun-* and the Australian *T. tonggol* and *T. mac-* The frigate mackerels (*Auxis*) and the tunnies or black skipjack (*Euthynnus*) have included, but the bonitos of the genus *Sarda* not. The compilers were spared having to any arbitrary decisions as to the status as of such borderline cases as the dogtoothed (*Gymnosarda*), the oriental bonito (*Kishino-* and the Spanish mackerels (*Scomberomorus*) e circumstance of their not finding any papers sively concerned with these fishes. Needless ay, the choice of scientific names used in king the bibliography is not meant to reflect taxonomic judgments but is based solely on iderations of convenience and familiarity. The ntific names employed in the various papers cited without change in the annotations, but been cross-referred to the appropriate category he index where there seemed to be no doubt o the synonymy.

The bibliography is a selective one, not only in the subject matter of the papers cited, but also with respect to their importance. While it has been impossible to set up hard-and-fast criteria of significance, every effort has been made to exclude material of an ephemeral or superficial nature, without overlooking any real contributions to knowledge concerning the tunas and their fisheries. In fields and areas where the literature is comparatively rich, it was possible to be more discriminating; in others more sparsely documented, the compilers had to take whatever they could find. In one case, that of the sizeable mass of annual Progress Reports covering semi-commercial fishing cruises by Japanese prefectural research vessels, which are published year after year with little variation in content, only representative samples of the more recent and comprehensive reports from each Prefecture have been included. In general, the compilers have sought papers of a solid scientific character, but such sources as fishery trade journals have not been passed over when they presented new information not more thoroughly covered elsewhere. Because of the inclusion of a number of papers which the compilers were unable to examine, it is possible that some items of little value have found their way into the collection. As completeness is a bibliographer's ideal most difficult of attainment, there may well be some important contributions that have evaded our search.

Annotations, following in general the pattern of those in Shimada's work, have been supplied for all items. The purpose is not to assess the value or reliability of the paper, but to give a clearer notion of content than can be gathered from a title. Papers which the compilers were not able to examine have the annotation limited to a statement of the categories under which the item was indexed. Some unevenness of treatment in the annotations is due to the fact that the compilers tried to annotate a little more fully than Shimada, but were under the necessity of borrowing his an-

notations verbatim for a number of items that he examined in Japan but could not bring back to the POFI library.

Papers are cited in alphabetical order by the authors' names and in chronological order under each author, and an abbreviated style has been used, the volume immediately following the name of the publication, the number next in parentheses, and the pagination following a colon. Titles of papers in European languages have been left in their original form, but those of Japanese items have been translated. A list is provided of full forms of names of periodicals abbreviated in the citations and of translations of names of Japanese journals. The abbreviations of American and European journal names follow the World List of Scientific Periodicals, 1900-50. Translations of the names of Japanese journals are given in brackets if supplied by the compilers and in parentheses if they appear, or have appeared in the past, on the journal. Japanese journals which have well-known and consistently used English names are cited by them in the bibliography, and the Japanese equivalents are supplied in the list. Japanese names were not abbreviated by the compilers, it being impracticable to do so with their Romanized forms. A few names abbreviated in Chinese characters in Japanese bibliographies have been cited as is, with the compilers' best guess as to their full forms.

A list of the major references and sources consulted in the compilation follows at the end of this introduction. In addition, reports and publications of various marine laboratories, too numerous to mention here, were checked. Often such publications are not indexed. In order to find out what had been published in Russian reports, inquiry was made of the Reference Department of the Library of Congress, and catalogue cards were received for those publications in the collection of the Library of Congress.

The compilers acknowledge gratefully the cooperation of the library staffs of the University of Hawaii, Pineapple Research Institute of Hawaii, Hawaiian Sugar Planters' Association, and the Bernice P. Bishop Museum in making their collections available. Invaluable assistance was given also by staff members of the libraries of the University of California (Berkeley and Los Angeles); Scripps Institution of Oceanography; and the Central Library of the U. S. Department of the Interior, in providing microfilm and photostatic copies of many items in the bibliography.

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LIST OF ABBREVIATIONS AND TRANSLATIONS OF PERIODICAL TITLES

A. Hancock Pacif. Exped.—Allan Hancock Pacific Expedition. Los Angeles.

Amer. Mus. Novit.—American Museum Novitates. New York.

Ann. biol., Copenhague.—Annales Biologiques. (Conseil Permanent International pour l'Exploration de la Mer.)

Ann. Inst. Océanogr.—Annales de L'Institut Océanographique. Paris.

Ann. Mag. nat. Hist.—Annals and Magazine of Natural History. London.

Ann. S. Afr. Mus.—Annals of the South African Museum. Cape Town.

Arch. Fischereiwiss.—Archiv für Fischereiwissenschaften.

Arch. Zool. exp. gen.—Archives de Zoologie Expérimentale et Générale. Paris.

Atti Conv. Biol. mar.—Atti del 2° Convegno di Biologia Marina. Messina.

Aust. J. Mar. Freshw. Res.—Australian Journal of Marine and Freshwater Research. Melbourne.

Aust. Zool.—Australian Zoologist. Sydney.

Ber. dtsch. Komm. Meeresforsch.—Bericht der Deutschen Wissenschaftlichen Kommission für Meeresforschung. Berlin.

Bibl. Ned. ind. nat. Ver.—Bibliotheek van de Nederlansch Indische Natuurhistorische Vereeniging. Batavia.

Biol. Bull., Shanghai.—Biological Bulletin of St. John's University. Shanghai.

Bol. Comp. Admin. Guano.—Boletín de la Compañía Administratora del Guano. Lima.

Bol. Dep. for. Mex.—Boletín del Departamento Forestal y de Caza y Pesca de Mexico.

Bol. Inst. esp. Oceanogr.—Boletín del Instituto Español de Oceanografía. Madrid.

Bol. Mus. Hst. nat. Prado.—Boletín del Museo de Historia Natural "Janvier Prado". Lima.

Bol. Oceanogr. Pesc., Madr.—Boletín de Oceanografía y Pescas. Madrid.

Boll. Mus. Zool. Anat. comp. Torino.—Bollettino dei Musei di Zoologia e di Anatomia Comparata della R. Università. Torino.

Boll. Pesca Piscic. Idrobiol.—Bollettino di Pesca, di Piscicoltura, e di Idrobiologia. Roma.

Boll. Zool. agr. Bachic.—Bollettino di Zoologia Agraria e Bachicoltura. Torino.

Broch. Sta. océanogr. Salammbô.—Brochure. Station Océanographique de Salammbô. Tunis.

Bull. Amer. Mus. nat. Hist.—Bulletin of the American Museum of Natural History. New York.

Bull. biogeogr. Soc. Japan.—Bulletin of the Biogeographical Society of Japan. Tokyo.

Bull. Fish. Res. Bd. Can.—Bulletin. Fisheries Research Board of Canada. Ottawa.

Bull. Fish. Soc. Philipp.—Bulletin of the Fisheries Society of the Phillippines.

Bull. Inst. océanogr. Monaco.—Bulletin de l'Institut Océanographique de Monaco.

Bull. Japan Sea reg. Fish. Res. Lab.—Bulletin of Japan Sea Regional Fisheries Research Laboratory (Nihonkaiku suisan kenkyūsho kenkyū hōkoku).

Bull. Jap. Soc. sci. Fish.—Bulletin of the Japanese Society of Scientific Fisheries (Nippon suisangakkai shi). Tokyo.

Bull. mar. Sci. Gulf Caribb.—Bulletin of Marine Science of the Gulf and Caribbean. Coral Gables, Fla.

Bull. Pacif. sci. Inst. Fish., Vladivostok.—Bulletin of the Pacific Scientific Institute of Fisheries and Oceanography. Vladivostok.

Bull. physiogr. Sci. Res. Inst. Tokyo Univ.—Bulletin of the Physiographical Science Research Institute, Tokyo University. (Tōkyō daigaku ritchi shizen kagaku kenkyūsho hōkoku). Tokyo.

Bull. Sch. Fish Hokkaido.—Bulletin of the School of Fisheries, Hokkaido Imp. University. Sapporo.

Bull. Scripps Instn. Oceanogr. tech.—Bulletin. Scripps Institution of Oceanography. Technical Series. La Jolla, Calif.

Bull. Serv. Élev. Industr. anim. A. O. F.—Bulletin des Services de l'Élevage et des Industries Animales de A. O. F. Dakar.

Bull. Soc. Océanogr. Fr. — Bulletin de la Société d'Océanographie de France. Paris.

Bull. Soc. portug. Sci. nat. — Bulletin de la Société Portugaise des Sciences Naturelles. Lisbon.

Bull. Soc. zool. Fr.—Bulletin de la Société Zoologique de France. Paris.

Bull. Sta. Aquic. Pêche Castiglione.—Bulletin de la Station d'Aquiculture et de Pêche de Castiglione. Algeria.

Bull. Sta. océanogr. Salammbô. — Bulletin. Station Océanographique de Salammbô. Tunis.

Bull. Tōhoku reg. Fish. Res. Lab.—Bulletin of Tōhoku Regional Fisheries Research Laboratory (Tōhoku kaiku suisan kenkyūsho kenkyū hōkoku).

Bull. U. S. nat. Mus.—Bulletin. United States National Museum. Smithsonian Institution. Washington

Fish. Min. Agr. and For.—Bureau of Fisheries. Ministry of Agriculture and Forestry. Japanese Imperial Government. (Suisankyoku. Nōrinshō. Dai Nippon Teikoku Seifu). Tokyo.

Acad. Sci., Paris.—Comptes Rendus, Académie des Sciences. Paris.

Ass. Anat.—Compte Rendu de l'Association des Anatomistes. Lisbonne.

Soc. Biogéographie.—Compte Rendu de la Société de Biogéographie. Paris.

Div. Fish Game. Bur. Mar. Fish. Mimeogr. Rep.—California. Division of Fish and Game. Bureau of Marine Fisheries.

Fish Game.—California Fish and Game. Sacramento.

Fish. Expt. Sta. Rep.—Central Fisheries Experiment Station Reports. (Suisan shikenjō chōsa hōkoku). Tokyo.

-ken suisan shikenjō jigyō hōkoku.—Progress Report of Chiba Prefectural Fisheries Experiment Station.

Pac. biol. Sta. Nanaimo.—Circular. Pacific Biological Station, Nanaimo, B. C.

U. S. Fish Wildl. Serv.—Circular of the United States Fish and Wildlife Service. Washington.

n. Fish. Rev.—Commercial Fisheries Review. U. S. Fish and Wildlife Service. Washington.

ib. cent. Fish. Sta. Japan—Contributions. Central Fisheries Station of Japan (Suisan shikenjō gyōseki shū). Tokyo.

ib. Nankai reg. Fish Res. Lab.—Contributions of Nankai Regional Fisheries Research Laboratory (Nankaiku suisan kenkyūsho gyōsekishū).

—Copeia. New York.

Pesca.—Corriere di Pesca. Roma.

o. flora.—Fauna och Flora. Uppsala.

ichthyol. Atlan. N.—Faune Ichthyologique de l'Atlantique Nord. Paris.

ull. F. A. O.—Fisheries Bulletin. Food and Agriculture Organization of the United Nations. Rome.

ull., Sacramento.—Fish Bulletin. California (Division of Fish and Game) Fish and Game Commission. Sacramento.

ry Bull., U. S.—Fishery Bulletin. Fish and Wildlife Service. Washington.

Div., FAO, U. N.—Fishery Division of the Food and Agriculture Organization of the United Nations. Washington.

Invest. (Suppl. Rep.), Imp. Fish. Exp. Sta.—Fishery Investigation (Supplementary Report). Imperial Fisheries Experiment Station. Tokyo.

Leafl., Wash.—Fishery Leaflet. Washington.

markt. Cuxhaven.—Fishmarket. Cuxhaven.

Fish. News Lett. Aust.—Fisheries News Letter, Council for Scientific and Industrial Research, Australia. Melbourne.

Fish. Progr. Rept.—Fisheries Progress Report. Division of Fish and Game, Board of Commissioners of Agriculture and Forestry, Territory of Hawaii.

Fish. Res. Progr. Rep.—See Fish. Progr. Rep.

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Hongkong Nat.—Hongkong Naturalist.

Ichth. Contr. Int. Game Fish Assoc.—Ichthyological Contributions of the International Game Fish Association. New York.

Int. Congr. Zool.—International Congress of Zoology.

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J. Commonw. sci industr. Res. Organ. Aust.—Journal of the Commonwealth Scientific and Industrial Reasearch Organization, Australia. Melbourne.

J. Cons. int. Explor. Mer.—Journal du Conseil Permanent International pour l'Exploration de la Mer. Copenhagen.

J. Coun. sci. ind. Res. Aust.—Journal of the Council for Scientific and Industrial Research, Australia. Melbourne.

J. Fac. Sci. Tokyo Univ.—Journal of the Faculty of Science, Tokyo Imperial University. Tokyo.

J. Fish. Res. Insti.—Journal of Fisheries Research Institute (Suisan kenkyūkai hō). Tokyo.

J. imp. Fish. Exp. Sta.—Journal of the Imperial Fisheries Experiment Station (Suisan shikenjō hōkoku). Tokyo.

J. Mar. biol. Assoc. U. K.—Journal of the Marine Biological Association of the United Kingdom. Plymouth.

J. Pan-Pacif. Res. Instn.—Journal of the Pan-Pacific Research Institution. Honolulu.

J. Tokyo Univ. Fish.—Journal of the Tokyo University of Fisheries. Yokosuka.

Jap J. Zool.—Japanese Journal of Zoology. Tokyo.

Kagaku.—[Science]. Tokyo.

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Katsuo to maguro.—[Skipjack and tuna]. (Organ of Federation of Japan Tuna and Bonito Fisheries Cooperative Associations).

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Mem. Bishop Mus.—Memoirs of the Bernice Pauahi Bishop Museum of Polynesian and Natural History. Honolulu.

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Mie sui shi jihō (Mie-ken suisan shikenjō jihō).—[Mie Prefecture Fisheries Experiment Station News Bulletin].

Miyagi no suisan.—[Miyagi Fisheries].

Miyagi Pref. Fish. Exp. Sta.—Miyagi Prefectural Fisheries Experiment Station. (Miyagi-ken suisan shikenjō). Watanoha.

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Nanyōchō suisan shikenjō jigyō hōkoku.—[Progress reports of the South Seas Government-General Fisheries Experiment Station]. Palau.

Nanyō suisan.—[South Sea Fisheries]. Tokyo.

Nanyō suisan jōhō.—[South Sea Fisheries News]. Palau.

Nat. E. Afr., Nairobi.—Nature in East Africa, Nairobi.

New Engl. Nat.—New England Naturalist. Boston.

N. Z. J. Sci. Tech.—New Zealand Journal of Science and Technology. Wellington.

Nippon kaiyōgakkai shi.—[Bulletin of the Oceanographical Society of Japan]. Tokyo.

Nissan Fish. Res. Sta.—Nissan Fisheries Research Station. (Nissan suisan kenkyūjo). Odawara.

Notas Inst. esp. Oceanogr.—Notas y resúmenes. Instituto Español de Oceanografía. Madrid.

Note Ist. Biol. mar. Rovigno.—Note dell' Istituto Italogermano di Biologia Marina de Rovigno d'Istria. Venezia.

Notes Sta. marit. Cauda.—Notes. Station Maritime de Cauda. Service (Institut) Océanographique et des Pêches de l'Indochine. Saigon.

Ōita-ken suisan shikenjō jigyō hōkoku.—Ōita Prefecture Fisheries Experiment Station Progress Report].

Okinawa-ken suisan shikenjō hōkoku.—[Okinawa Prefecture Fishery Experiment Station Report].

Okinawa-ken suisan shikenjō jigyō hōkoku.—[Okinawa Prefecture Fisheries Experiment Station Progress Reports].

Ōyō kishō.—[Applied Meteorology]. Tokyo.

Pacif. Fisherm.—Pacific Fisherman. Seattle, Wash.

Pacif. Sci.—Pacific Science. Honolulu.

Palao trop. biol. Stud.—Palao Tropical Biological Station Studies. Tokyo.

Pamphl. Coun. sci. ind. Res. Aust.—Pamphlet. Council for Scientific and Industrial Research, Australia. Melbourne.

Pan-Amer. Fish.—Pan-American Fisherman. San Diego.

Philipp. J. Sci.—Philippine Journal of Science.

Proc. Acad. nat. Sci. Philad.—Proceedings of the Academy of Natural Sciences of Philadelphia.

Priroda. Zagreb.

Proc. Gulf and Caribbean Fish. Inst.—Proceedings of the Gulf and Caribbean Fisheries Institute.

Proc. Indo-Pacif. Fish. Coun.—Proceedings. Indo-Pacific Fisheries Council. Bangkok.

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o. Cons. Explor. Mer.—Rapport et Procès-verbaux des Réunions. Conseil Permanent International pour l'Exploration de la Mer. Copenhagen.

Albany Mus.—Records of the Albany Museum. Grahamstown.

Canterbury (N. Z.) Mus.—Records of the Canterbury Museum. Christchurch, N. Z.

oceanogr. Wks. Jap.—Records of Oceanographic Works in Japan.

ort of Survey for Tuna Fishing (Maguro gyogyō chōsa hōkoku).—See Tuna Fishing.

Rep. U. S. Fish Serv.—Research Report. U. S. Fish and Wildlife Service. Washington.

. Sci.—Revue Scientifique. Paris.

. Trav. Inst. sci. tech. Pêches marit.—Revue des Travaux de l'Institut Scientifique et Technique des Pêches Maritimes. Paris.

. Trav. Off. Pêches marit.—Revue des Travaux de l'Office des Pêches Maritimes. Paris.

arski kalendar. Split.

mnu. Rep. oceanogr. Invest., Tokyo.—Semi-annual Report of Oceanographical Investigations. Imperial Fisheries Institute. Tokyo.

ea Sci.—South Sea Science (Kagaku nanyō). Palau.

AP Nat. Resour. Sect. Rep.—Supreme Commander for the Allied Powers. General Headquarters. Natural Resources Section. Reports. Tokyo.

Mon., N. Y.—Scientific Monthly. New York.

Progr. Twent. Cent.—Science Progress in the Twentieth Century. London.

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abutsu oyobi dōbutsu.—[Plants and animals]. Tokyo.

thson. misc. Coll.—Smithsonian Miscellaneous Collections. Washington.

c. sci. Rep: Fish., U. S. Fish Wildl.—Special Scientific Report: Fisheries. U. S. Fish and Wildlife Service. Washington.

nf. ichthyol. Bull.—Stanford Ichthyological Bulletin. Palo Alto.

san butsuri danwakai kaihō.—[Bulletin of the Fisheries Physics Discussion Group]. Tokyo.

san gakkwai hō.—(Proceedings of the Scientific Fisheries Association). Tokyo.

sankai.—(Journal of the Fisheries Society of Japan). Tokyo.

san kenkyū shi.—[Journal of Fisheries Research]. Tokyo.

Suisan kōza.—(The text of the Fishery). Tokyo.

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J = in Japanese only.
JE = published in Japan but written in English.
Je = in Japanese with an English abstract.
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1938. On a report of investigations of summer albacore. Kaiyō gyogyō 3(4):14-31. [J]
Germo alalunga: Pacific Ocean-northwest.

TAI, SHINKISHI, ET AL.
1941. A symposium on the investigation of skipjack and tuna spawning grounds. Kagaku nanyō 4(1):64-75. (Pacific Oceanic Fishery Investigations Translation No. 16. In: Spec. sci. Rep: Fish. U. S. Fish Wildl. 18). [P]
Skipjack: Japan, Indonesian waters, South Seas; eggs, juveniles, food, migration, sexual maturity, method of determining male and female skipjack. Black tuna: Japan, Philippine region; probable spawning areas and season, sexual maturity, eggs. Yellowfin tuna: sexual maturity and probable spawning season in the Indo-Pacific area. Bigeye tuna: juveniles.

HATAI, SHINKISHI ET AL.—Continued

HELDT, H.
1930. Le thon rouge et sa pêche, nouveaux aspects de la question. Bull. Sta. océanogr. Salammbô 18:69 p. [P]
Thunnus thynnus: synonymy, anatomy, distribution, food, migrations, tropisms, spawning, growth, catch statistics, bibliography.

1931. *Thunnus thynnus*. In: Faune Ichthyologique de l'Atlantique Nord, No. 7. [P]
Distribution, figure, description, brief synonymy.

1931. Le thon rouge et sa pêche, éléments d'un nouveau rapport. Bull. Sta. océanogr. Salammbô 21:165 p. [P]
Thunnus thynnus: figured, synonymy, morphology, compared with *T. secundodorsalis*, biometry, meristic counts, distribution, migrations, spawning, growth, fishing methods, utilization, catch statistics, bibliography.

1932a. Repérage des bancs de thons par avion. Notes Sta. océanogr. Salammbô 26:12 p. [P]
Aerial scouting for tuna schools in trap fishery off Moroccan coast; discussion of application of aircraft to tuna fishing and to the study of tuna migrations.

1932b. Le thon rouge et sa pêche, rapport pour 1931. Bull. Sta. océanogr. Salammbô 29: 168 p. [P]
Thunnus thynnus: figured, synonymy, "facial anomaly," meristic counts, distribution, migrations; tags, hooks, and harpoons figured; spawning, growth; fishing methods and gear, especially purse seine and trap; catch statistics, bibliography.

1934. Le thon rouge et sa pêche. Rapp. Comm. int. Mer Médit. 8:187-255.
Thunnus thynnus: food, migration, spawning, statistics, development, bibliography.

1937. Le thon rouge et sa pêche, rapport pour les années 1933, 1934, et 1935 (9e Rapport). Rapp. Comm. int. Mer Médit. 10:235-315.
Thunnus thynnus: bionomics and fishery.

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Thunnus thynnus: bionomics.

HELDT, H.—Continued

1943. Études sur le thon, la daurade, et les muges. Histoires d'écailles et d'hameçons. Broch Sta. océanogr. Salammbô 1.
Thunnus thynnus: growth; migration; Mediterranean Sea.

1950. Le germon *(Germo alalunga* Gmelin). Étude biologique d'après l'éxamen des écailles. Ann. biol., Copenhague 7:63-64. [P]
Scale reading; age and growth.

HERALD, EARL S.

1949. Pipefishes and seahorses as food for tuna. Calif. Fish Game 35(4):329. [P]
Euthynnus yaito, yellowfin tuna: stomach contents.

1951. Pseudofins on the caudal peduncle of juvenile scombroids. Calif. Fish Game 37(3): 335-337. [P]
Auxis thazard, Katsuwonus pelamis.

HERRE, ALBERT W. C. T.

1932. A check list of fishes recorded from Tahiti. J. Pan-Pacif. Res. Instn. 7(1):3. [P]
Euthynnus alletteratus, E. pelamis, Neothunnus macropterus: listed.

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Euthynnus yaito, Katsuwonus pelamis: listed.

1935. A check list of the fishes of the Pelew Islands. Mid-Pacif. Mag. 47(2):164. [P]
Katsuwonus pelamis, Neothunnus macropterus: listed.

1936. Fishes of the Crane Pacific Expedition. Zool. Ser. Field Mus. nat. Hist. 21:105-107.
Katsuwonus pelamis, Neothunnus macropterus, Thunnus thynnus: distribution, synonymy, observations on *N. macropterus* fin lengths.

1940. Distribution of the mackerel-like fishes in the western Pacific north of the Equator. Proc. Pacif. Sci. Congr. 6th, vol. 3:211-215. [P]
Auxis thazard, Euthynnus alletteratus, E. yaito, Germo alalunga, Katsuwonus pelamis, Neothunnus macropterus, N. rarus, Parathunnus sibi, Thunnus thynnus: distribution.

1953. Check list of Philippine fishes. Res. Rep. U. S. Fish Wildl. 20:977.
Synonymy, range.

HERRE, ALBERT W. C. T., and A. F. UMALI.

1948. English and local common names of Philippine fishes. Circ. U. S. Fish Wildl. Serv. 14: 128 p. [P]

HERRE, ALBERT W. C. T., and A. F. UMALI.—Continued
Auxis thazard, Euthynnus yaito, Germo alalunga, Katsuwonus pelamis, Neothunnus macropterus: listed.

HIATT, R. W., and V. E. BROCK.

1948. On the herding of prey and schooling of the black skipjack, *Euthynnus yaito* Kishinouye. Pac. Sci. 2(4):297-298. [P]
Euthynnus yaito: observations of herding of scads, *Decapterus sanctae-helenae,* in the Marshall Is.

HIGASHI, HIDEO.

1940a. Utilization of fishery byproducts from the South Seas (3). Nanyō suisan 6(7):13-20. [J,P]
Bigeye tuna, black tuna, skipjack, yellowfin tuna: ratio of viscera weight to body weight.

1940b. Utilization of fishery byproducts from the South Seas (7). Nanyō suisan 6(12):10-13. [J,P]
Skipjack: ratio of viscera weight to body weight; proportional measurements of various body parts.

1941a. Utilization of fishery byproducts from the South Seas (10). Nanyō suisan 7(3):32-39. [J,P]
Katsuwonus vagans, Neothunnus macropterus: proportional measurements of various body parts; age analysis.

1941b. Utilization of fishery byproducts from the South Seas (14). Nanyō suisan 7(8):36-43. [J,P]
Bigeye tuna, yellowfin tuna: length-weight data; proportional measurements of various body parts; liver figured.

1942. Record of experiments on fishes of the South Seas. Nanyō suisan 8(11):13-27 [J,P]
Katsuwonus vagans, Neothunnus macropterus, Parathunnus sibi: length-weight data; proportional measurements of various body parts.

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1948. The nicotinic acid content of fish. Contrib. cent. Fish Sta. Japan (1946-1948) 18:129-132.
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HILDEBRAND, SAMUEL F.

1946. A descriptive catalog of the shore fishes of Peru. Bull. U. S. nat. Mus. 189:361-372. [P]
Euthynnus alletteratus, Katsuwonus pelamis, Thunnus macropterus: classification; description, synonymy; distribution, food, key. *Thunnus germo, T. thynnus*: key, occurrences recorded.

ATSUKA, HITOSHI, and KAKUJI IMAIZUMI.
1934. Experimental fishing and investigation in southern waters by the Shōnan Maru. Taiwan sōtokufu suisan shikenjo jigyō hōkoku (gyorōbu) 1932:97-164. [J,P]
Yellowfin tuna: Indo-Pacific region; length-weight data, fishing conditions in relation to oceanography and weather; catch per unit of effort; distribution.

RATSUKA, HITOSHI, and KIYOJI ITŌ.
1934. Report on experimental tuna fishing in the Celebes Sea. Taiwan sōtokufu suisan shikenjō jigyō hōkoku 1934:1-28. [J,P]
Yellowfin tuna: length-weight data; fishing conditions in relation to oceanography and weather; catch per unit of effort; distribution.

RATSUKA, HITOSHI, and SEIICHI MORITA.
1935. Correlation between length and weight of yellowfin tuna. Taiwan suisan zasshi 241: 8-10. (Pacific Oceanic Fishery Investigations Translation No. 26. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 22). [P]
Neothunnus macropterus: Celebes Sea; morphometrics.

1936. Correlation between length and weight of yellowfin tuna from the Celebes Sea. Suisan kenkyū shi 31(1):67-68. [J]
Neothunnus macropterus: length-weight relationship; Celebes Sea.

RTZ, M.
1933. O tuni i tunolovu. Priroda 23(10):318-320.
Adriatic Sea, fishing gear and methods.

RIGUCHI, YOSHISHIGE, D. KAKIMOTO, and KENICHI KASHIWADA.
1950. The distribution of inosite in the skipjack (*Katsuwonus pelamis*). Kagoshima sui sen ken hō 1:41-46. [J]
Chemical analysis.

RIGUCHI, YOSHISHIGE, KENICHI KASHIWADA, and DAIICHI KAKIMOTO.
1953. Biochemical studies on skipjack, *Katsuwonus vagans*. II. Contents of inorganic substances in pyloric caeca. Bull. Jap. Soc. sci. Fish. 18(7):279-282. [Je,P]
Qualitative and quantitative analysis of the inorganic content of the pyloric caeca; quantitative results compared with those from analysis of muscle tissue.

HISA, SATORU.
1939. Catch of tunny in the seas south of Kyushu. Bull. Jap. Soc. sci. Fish. 8(3):143-144. [Je,P]
Thunnus orientalis: catches correlated with water temperature.

IKEBE, KENZŌ.
1938. Progress report on skipjack baitfish holding experiments. Nanyō suisan jōhō 2(4): 2-4. [J,P]
Skipjack live bait fishing: mortality of baitfish (*Spratelloides delicatulus?*) held in pound net at Palau; water temperature, salinity, specific gravity.

1939a-1940. Four papers on the morphometry and age of tropical tunas. Nanyō suisan jōhō 3(10):4 p; 4(1):3 p; 4(2):4 p; 4(5):5 p. Pacific Oceanic Fishery Investigations Translation No. 34. In: Spec. sci. Rep: Fish U. S. Fish Wildl. 22). [P]
Length and weight data on *Neothunnus macropterus, Makaira mitsukurii, Parathunnus mebachi,* and *Thunnus germo* from Palau, the Marshalls, and Saipan; ages given based on Aikawa's age-size tables.

1939b. On the age of yellowfin taken in Palau waters. Nanyō suisan jōhō 3(10):4-8. [J,P]
Length-weight data, body condition, sexual maturity; age analysis based on size groups according to Aikawa's tables.

1940a. Age and measurements of tunas in Palau waters. Nanyō suisan jōhō 4(1):2-4. [J,P]
Bigeye tuna, yellowfin tuna, striped marlin: length-weight data, condition factor; age analysis of yellowfin tuna based on size groups in accordance with Aikawa's tables.

1940b. Measurements of yellowfin tuna taken south of the Marshall Islands. Nanyō suisan jōhō 4 (2):2-5. [J,P]
Length-weight data on longline-caught fish, a total of 75 from 6 stations; age analysis based on size according to Aikawa's tables.

1940c. Measurements of albacore and yellowfin tuna taken in Saipan waters. Nanyō suisan jōhō 4(5):63-67. [J,P]
Lengths and weights (gutted) of 8 albacore and 58 yellowfin taken on longlines north of Saipan; age analysis according to Aikawa's size age tables.

1940d. Investigation of tunas in Palau waters. Nanyō suisan jōhō 4(6):2-4. [J,P]
Catches at 14 longlining stations near 7° N., 134°E.; surface temperatures and currents noted; catch rates for yellowfin and spearfishes combined.

1941a. A survey of tuna fishing grounds in the Marshall and Caroline islands. Nanyō suisan jōhō 5(1):6-9. (Pacific Oceanic Fish-

IKEBE, KENZŌ.—Continued
ery Investigations Translation No. 15 In: Spec. sci. Rep.: Fish. U. S. Fish Wild. 47) [P]
Catches from exploratory longlining in the Equatorial Countercurrent; currents at 10 fishing stations recorded; catch rates for tunas and marlins combined.

1941b. Measurements of yellowfin tuna from the Equatorial Countercurrent area. Nanyō suisan jōhō 5(3):5-13. [J,P]
Lengths, weights, sex, and estimated age (from Aikawa's tables) of 188 longline-caught yellowfin from 8 stations in southern Carolines waters.

1941c. A contribution to the study of tuna spawning grounds. Nanyō suisan jōhō 5(4):9-12. [J,P]
South Seas: probable tuna spawning grounds; lengths, weights, and estimated ages of 20 juvenile yellowfin, with dates and positions of capture.

1942. Report of the investigation of tuna fishing in the Timor, Arafura, and Banda seas. Nanyō suisan 8(1):29-41. (Pacific Oceanic Fishery Investigations Translation No. 48. In: Spec. Sci. Rep: Fish. U. S. Fish Wildl. 45) [P]
Bigeye tuna, yellowfin tuna: longline fishing conditions in relation to oceanography; catches and catch rates at 10 stations.

IKEBE, KENZŌ, and TAKESHI MATSUMOTO.
1937. Progress report on experimental skipjack fishing near Yap. Nanyō suisan jōhō 1(4):3-9. (Pacific Oceanic Fishery Investigations Translation No. 6. In: Spec. sci. Rep.: Fish. U. S. Fildl. 46) [P]
Results of 10 days' livebait fishing around Yap: fishing logs; lengths, weights, sex, and condition factor for 83 skipjack; water temperatures and salinities to 200 m. at 8 stations.

1938. Report of a skipjack bait investigation in Saipan waters. Nanyō suisan jōhō 6:2-12. (Pacific Oceanic Fishery Investigations Translation No. 30. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 44). [P]
Common names and descriptions of the species used for livebait at Saipan; results of intensive experimental fishing for livebait.

IKEDA, NOBUYA.
1932. The bait problem and the development of our skipjack and mackerel fisheries. Miyagi no suisan 1:9-29. [J]
Katsuwonus pelamis, Pacific Ocean-northwest; livebait fishing.

IKEDA, NOBUYA, and SEIJI ANDŌ.
1933. A consideration of skipjack fishing conditions off northeastern Japan in 1930. Gyorō kenkyūkai kaihō 5. [J]
Katsuwonus pelamis, Pacific Ocean-northwest.

IKEHARA, ISAAC I.
1953. Live-bait fishing for tuna in the central Pacific. Spec. sci. Rep.: Fish. U. S. Fish Wildl. 107:20 p. [P]
Availability and characteristics of livebait species of the Hawaiian, Line, and Phoenix islands; results of exploratory livebait fishing around these groups; size frequency distribution of yellowfin tuna caught by livebait fishing in Line and Phoenix islands; evaluation of baiting grounds in the area.

IMAI, SADAHIKO.
1950. Studies on flying fishes. 1. On the young of flying fishes eaten by tuna. Kagoshima sui sen ken hō 1:137-148. [J]
Tuna: food.

IMAIZUMI, KAKUJI.
1937. An account of the investigation of tuna fishing grounds in the East Philippine Sea. Taiwan suisan zasshi 271:6-23. [J,P]
Popular account of an exploratory tuna longlining expedition: total catch and catch rates by species for 17 stations; brief remarks on maturity of yellowfin, distribution of catch rates, and oceanographic conditions.

IMAMURA, YUTAKA.
1949. The skipjack fishery. Suisan kōza 6:17-94. (Pacific Oceanic Fishery Investigations Translation No. 32. In: Spec. sci Rep.: Fish. U. S. Fish Wildl. 49). [P]
Auxis hira, A. maru, Euthynnus yaito: Japan; description, distribution, habits. *Katsuwonus pelamis*: Japan; anatomy, description, migration, spawning areas and seasons, food, populations, habits, natural enemies, fishing conditions in relation to oceanography.

1953. The tuna fishery. Suisan kōza 6:104 p. Tōkyō. [J,P]
General account of tuna livebait fishing, purse seining, gillnetting, trolling, and longlining; tables of operating and economic data on Japanese longliners.

INANAMI, YOSHIYUKI.
1940a. Relationship of viscera weight to body weight in yellowfin tuna. Nanyō suisan jōhō 4(2):2-7. [J,P]
Length, weight, body depth, body breadth,

AMI, YOSHIYUKI.—Continued

and weight of gills and viscera for 13 large longline-caught yellowfin; percentage of gill-and-viscera weight in body weight calculated.

1940b. Oceanography and fishing conditions in the sea area centered on Palau. Nanyō suisan jōhō 4(3):5-7. [J,P]

Bigeye tuna, yellowfin tuna: longline fishing conditions in relation to currents and water color.

1940c. Tuna fishing conditions and currents along the eastern coast of the Palau Islands. Nanyō suisan jōhō 4(2):7-10. [J,P]

Bigeye tuna, yellowfin tuna: longline fishing conditions in relation to local currents at 47 stations within 30 miles of the coast.

1941. Report of oceanographic changes and fishing conditions in Palau waters. Nanyō suisan jōhō 5(2):2-6. (Pacific Oceanic Fishery Investigations Translation No. 3. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 42) [P]

Describes the effects of a southward shift of the Equatorial Counter-current on oceanographic conditions and on the skipjack fishing at Palau.

1942a. Oceanographic conditions and yellowfin tuna fishing grounds in South Sea Islands waters. Nanyō suisan jōhō 6(1):2-5. [J,P]

Location of longline fishing grounds in relation to currents, transparency, water color, and water temperature in the equatorial current system between 130°E. and 170°E. longitude.

1942b. Skipjack fishing conditions at Saipan, Truk, and Ponape. Nanyō suisan jōhō 6(1):5-7. [J,P]

Seasonal fluctuations in commercial catch and the size of fish taken.

1942c. Small skipjack caught at Truk. Nanyō suisan jōhō 6(1):7. [J,P]

Records and measurements of two juveniles.

1942d. Grounds fished by tuna boats operating in the Inner South Seas. Nanyō suisan jōhō 6(1): 7-9. [J,P]

Albacore, bigeye, skipjack, yellowfin tuna: fishing conditions in relation to water temperature; seasonal shifts in equatorial longlining grounds at 150°E. to 160°E. longitude.

UE, MOTOO.

1953. Albacore fishing conditions and oceanographic conditions in the 1952-53 longlining season. Tōkai daigaku sangyō kagaku kenkyūsho suisan kenkyūbu gyogyō shiryō No. 3:17 p. [J,P]

Thunnus germo: fishing conditions in relation to oceanography, catch per unit of effort; Pacific Ocean—northwest.

INOUE, MOTOO.—Continued

ISAWA, TAKAO.

1935. On the tuna of the Japan Sea coast of Hokkaidō. Hokkaidō sui shi junpō 1935:727-731. [J]

Tuna: distribution; Sea of Japan.

IWATE PREFECTURE FISHERIES EXPERIMENT STATION.

1953a. South Seas tuna fishing experiment report. 1:44 p. [J,P]

Results of an exploratory longlining trip around 10°N., 170°W. Fishing logs; currents, salinities and water temperatures to 300 m., plankton collections; distribution of catch rates for *N. macropterus, P. sibi,* and black marlin; length frequency curves, sex ratios and apparent maturity, notes on stomach contents, catch by branch line number and estimated depth; data on shipboard refrigeration and the prices received from each species landed.

1953b. South Seas tuna fishing experiment report. 2:31 p. [J,P]

Results of an experimental longlining trip around 4°N., 175°W. Fishing logs; currents, water temperatures and salinities to 300 m., plankton collections; length frequency distributions for *N. macropterus, P. sibi,* and black marlin; catch rates; catch by branch line numbers and estimated depts; prices received for each species landed; sex ratios and apparent maturity.

JAPANESE BUREAU OF FISHERIES.

1933. Report of the southern fisheries investigation for 1931. Bur. Fish. Min. Agr. and For. (1931) 1933:96 p. [J,P]

Results of tuna longlining and purse seining by boats of the training ship Hakuyō Maru in the Celebes Sea and Indian Ocean; shipboard tuna canning experiment; complete logistical and operational data; catch and production (dried fish) of a land-based skipjack fishing operation in Borneo; fishing gear and boats described and figured; yellowfin and bigeye catch, catch rates, weather, and oceanographic data for 19 longline stations; observations of surface schools of skipjack and small yellowfin.

1934. Report of the southern fisheries investigation for 1932. Bur. Fish. Min. Agr. and For.

JAPANESE BUREAU OF FISHERIES.—Continued

(1932) 1934: 347 p. [J,P]

Results of tuna longlining and purse seining by boats of the factory ship Haruna Maru (1,500 tons) off the N. coast of Borneo and the W. coast of Sumatra; complete operational data; results of shipboard canning and freezing experiments; descriptions and figures of fishing gear and boats; daily catches by species by each of 8 boats fishing up to 40 baskets of longlines; catch rates given, positions of sets plotted; yellowfin stomach contents (nonquantitative) recorded for 66 samples of up to 29 fish, together with notes on plankton samples from the same stations; graph plotting yellowfin and bigeye catch rates with transparency and water temperature at 0, 100, and 150 meters.

1935. Report of the southern fisheries investigation for 1933. Bur. Fish. Min. Agr. and For. (1933) 1935: 298 p. [J,P]

Results of tuna longlining and purse seining by boats of the factory ship Haruna Maru (1,500 tons) off south coasts of Sumatra, Java, and the lesser Sundas; complete operational data; shipboard canning and freezing results; fishing logs and catch data for 67 longlining stations; water temperature and specific gravities to 200 m. given as high, low, and average for each of three sections of cruise; total catch rates (all species) given similarly; details of longline and purse seine construction; descriptions of boats used; description of processing techniques; tuna catch comprised yellowfin and bigeye.

1939. Results of encouragement given to the development of albacore fishing grounds during 1938. Bur. Fish., Min. Agr. and For. 1939: 298 p. [J,P]

Detailed results of exploratory albacore longlining by 11 research ships at 28°N.-43°N., 165°E.-165°W. from May to September; track charts and fishing logs; data on surface and subsurface water temperatures and salinities, correlated with catch rates; albacore stomach contents noted; measurement and sex data; catch records also for bigeye, yellowfin, and skipjack.

1940. Results of encouragement given to the development of albacore fishing grounds during 1939. Bur. Fish., Min. Agr. and For. 1940: 173 p. (Translated as Spec. sci. Rep.: Fish. U. S. Fish Wildl. 33). [P]

Detailed results of exploratory albacore longline fishing by 9 research ships at 30° N.-45°N., 163°E.-175°W. from May through October; track charts and fishing logs; data on surface and subsurface water temperatures and salinities, correlated with albacore catch rates; stomach contents noted; measurement and sex data; catch records for bigeye also; data on plankton collections (nonquantitative).

1942. Results of encouragement given to the development of albacore fishing grounds during 1940. Bur. Fish. Min. Agr. and For. 1940: 135 p. [J]

Results of exploratory albacore longlining in the central North Pacific.

JOUBIN, M. (ED.)

1934. Faune Ichthyologique de l'Atlantique Nord, No. 15. Copenhagen, Andr. Fred Høst and Fils (published for Conseil Permanent International pour l'Exploration de la Mer). [P]

Plates including description, synonymy, geographical distribution of: *Germo alalunga, Auxis thazard, Katsuwonus pelamis, Euthynnus alletteratus, Sarda sarda.*

JUNE, FRED C.

1950a. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part 1. The Hawaiian long-line fishery. Comm. Fish. Rev. 12(1):1-23. [P]

Information on the boat, crew, description of gear, bait, setting the line, fishing areas and depths, amount and efficiency of gear used, catch composition.

1950b. The tuna industry in Hawaii. Pan-Amer. Fish. 4(10):11, 19. [P]

Brief description of the skipjack *(Katsuwonus pelamis)* fishery.

1951a. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part 2. Notes on the tuna and bait resources of the Hawaiian, Leeward, and Line Islands. Comm. Fish. Rev. 13(1):1-22. [P]

Includes sea conditions, tuna and bait resources, for the Hawaiian Islands, Leeward Islands, Line Islands, and Canton Island.

1951b. Preliminary fisheries survey of the Hawaiian Line Islands area. Part 3. The live-bait skipjack fishery of the Hawaiian Islands. Comm. Fish. Rev. 13(2):1-18. [P]

Description and notes on biology of skipjack, development of the fishery, fishing boats and crews, bait, fishing methods, fishing areas and seasons.

1952a. Observations on a specimen of bluefin tuna (*Thunnus thynnus*) taken in Hawaiian waters. Pacif. Sci. 6(1):75-76. [P]

Comparison with *Thunnus orientalis;* mor-

E, FRED C.—Continued

phometric measurements and meristic counts of the specimen given.

1952b. An "unusual" yellowfin tuna (*Neothunnus macropterus*) from the waters of the northern Line Islands in the central Pacific Ocean. Copeia 1952 (3):210-211. [P]

Description of a 24-lb. female which because of its coloration at first appeared to be a bluefin tuna (*Thunnus thynnus*) or *Thunnus maccoyi*. Meristic counts and measurements indicated that it was a yellowfin tuna.

1953. Spawning of yellowfin tuna in Hawaiian waters. Fish. Bull., U. S., 54(77):47-64. [P]

Collection and treatment of ovary samples, description of the ovaries, development of the ova, relation of ovary size to fish size as a measure of maturity, number of ova spawned, spawning season, spawning and the fishing season.

NE, FRED C., and J. W. REINTJES.

1953. Common tuna-bait fishes of the central Pacific. Res. Rep. U. S. Fish. Wildl. 34:54 p. [P]

Keys and descriptions of families and species of bait fishes; figures; evaluation of tuna bait resources in the central Pacific.

IUKU, TAKEICHIRŌ.

1950. On the dark muscle tissue in fishes. (Rep. No. 1.) The dark muscle tissue of the tunas. from the viewpoint of comparative anatomy. Jap. J. Ichth., Tokyo 1(2):89-100. [Je,P]

Tuna: anatomy.

AGOSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.

1930a. Experimental skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1928):1-18. [J,P]

Results of 11 skipjack livebait fishing cruises off southern Japan, the Ryukyus, and northern Formosa from March to June: fishing logs; surface and subsurface water temperatures at fishing stations.

1930b. Experimental longline fishing for tuna. Kagoshima-ken suisan shikenjō jigyō hōkoku (1928):18-31. [J,P]

Results of 3 longlining cruises from southern Japan to the Ryukyus between November and February; bigeye, yellowfin, and albacore catches, correlated with tides; surface and subsurface water temperatures at fishing stations; fishing logs.

1930c. Experimental fishing by small motor vessels: experimental longline fishing for albacore. Kagoshima-ken suisan shikenjō jigyō hōkoku (1928):54-60.

KAGOSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

Results of 2 longlining cruises with a 20-ton vessel in Ryukyu waters in March and April; description of gear; albacore, yellowfin, and bigeye catch, surface and subsurface water temperatures at fishing stations; fishing logs, plots of sets.

1931a. Experimental skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1929):1-16. [J,P]

Results of 10 livebait skipjack fishing cruises in Ryukyu waters between March and June; average monthly surface water temperatures for 7 years; commercial fishing correlated with surface temperatures; a few subsurface temperature data; fishing logs.

1931b. Experimental longline fishing for tuna. Kagoshima-ken suisan shikenjō jigyō hōkoku (1929):16-30. [J,P]

Results of 4 exploratory tuna longlining cruises in Ryukyu waters from October to January; average monthly water temperatures; catches of yellowfin, albacore, and bigeye tuna recorded with surface and subsurface temperatures at the stations, moon phase and tides, transparency; description of gear; plot of station locations and fishing logs.

1932a. Experimental skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1930):1-20. [J,P]

Results of 9 livebait skipjack fishing cruises in Ryukyu waters from March to June; surface water temperature isotherms plotted; fishing logs and plot of station locations.

1932b. Experimental longline fishing for tuna. Kagoshima-ken suisan shikenjō jigyō hōkoku (1930):21-28. [J,P]

Results of 7 exploratory tuna longlining cruises in Ryukyu waters from October to February; catches of yellowfin, bigeye, and black tuna recorded with surface and subsurface temperatures at fishing stations; fishing logs and plot of station locations.

1932c. Experimental longline fishing for albacore and pole and line fishing for mackerel. Kagoshima-ken suisan shikenjō jigyō hōkoku (1930) 54-59. [J,P]

Results of 3 exploratory longlining stations in Ryukyu waters in March; catch (a total of 3 albacore) recorded with surface and subsurface temperatures on the stations; fishing logs and plot of station locations.

KAGOSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

1933a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1931): 1-16. [J,P]

Results of 8 exploratory live-bait skipjack fishing cruises in Ryukyu, Formosan, and Philippines waters from March to June; fishing logs and plots of station locations; surface temperatures discussed, isotherms plotted.

1933b. Experimental longline fishing for tuna. Kagoshima-ken suisan shikenjō jigyō hōkoku (1931):16-23. [J,P]

Results of 3 exploratory tuna longlining cruises (23 stations) in Ryukyu waters in October-December; fishing logs and plots of station locations; yellowfin, albacore, and bigeye catch recorded with surface and subsurface temperatures and salinities, transparencies, on the stations; total catch rates averaged by area.

1934. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1932): 1-27. [J,P]

Results of 8 exploratory skipjack live-bait fishing cruises in Ryukyu waters from February to June; fishing logs and plot of station locations; water temperature distribution discussed with data on commercial landings at local ports.

1935a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1933): 1-13. [J,P]

Results of 9 exploratory skipjack live-bait fishing cruises in Ryukyu waters from March to June; fishing logs and plot of station locations; water temperature distribution discussed with data on commercial landings at local ports.

1935b. Cooperative South Seas tuna fishing survey. Kagoshima-ken suisan shikenjō jigyō hōkoku (1933):15-21. [J,P]

Results of 4 combination skipjack live-bait and tuna longlining exploratory cruises in the Sulu and Celebes seas by subsidized commercial vessels; catch rates for total tuna, species not recorded.

1936a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1934):1-16. [J,P]

Results of 10 exploratory skipjack live-bait fishing cruises in Ryukyu waters from March to June; discussion of water temperatures and fishing conditions; commercial landings at local ports; lengths and weights of 728 skipjack, average condition factors of samples.

KAGOSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

1936b. Cooperative southern skipjack fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1934):17-21. [J,P]

Results of 4 exploratory skipjack live-bait fishing cruises in the Sulu and Celebes seas by a subsidized commercial vessel; chart of locations fished; notes on feeding and care of live-bait.

1936c. Investigation of the migration of important fishes. Kagoshima-ken suisan shikenjō jigyō hōkoku (1934):86-87 [J,P]

Release records of 45 skipjack tagged on the caudal peduncle in Ryukyu waters.

1937a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1935) 1-8. [J,P]

Results of 8 exploratory skipjack live-bait fishing cruises in Ryukyu waters from February to June discussed in relation to surface water temperatures; data on landings at local ports by months; average weights, lengths, and condition factors of ten 50-fish samples; distribution of water temperatures and skipjack fishing grounds recorded and plotted for several years; seasonal and annual variations in size composition of the catch; fishing logs and station plots.

1937b. Cooperative southern tuna fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1935):9-11. [J,P]

Results of 4 combination skipjack live-bait fishing and tuna longline exploratory cruises to the Sulu Sea; skipjack, yellowfin, and bigeye catches recorded, fishing locations plotted.

1937c. Survey of the present condition of the skipjack fishing industry. Kagoshima-ken suisan shikenjō jigyō hōkoku (1935):96-103. [J,P]

Numbers of skipjack vessels by size classes in the prefecture, their equipment and operating regime; economic and financial data on the fishery.

1938a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1936):1-4. [J,P]

Results of 9 exploratory skipjack live-bait fishing cruises in Ryukyu waters from February to July; discussion of water temperature in relation to fishing conditions; monthly skipjack landings at local ports; average lengths and weights of fifteen 20-fish samples; fishing logs and station plot.

OSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

1938b. Cooperative southern skipjack fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1936):7-10. [J,P]
Results of 2 exploratory skipjack fishing cruises in the Celebes and Sulu seas from November to February by a subsidized commercial vessel.

1938c. Investigation of the migration of important fishes. Kagoshima-ken suisan shikenjō jigyō hōkoku (1936):89. [J,P]
Release records for 45 skipjack tagged in Ryukyu waters.

1939a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1937):1-3. [J,P]
Results of 7 exploratory skipjack live-bait fishing cruises in Ryukyu waters from March to June; fishing logs and plot of stations; average length and weight of 8 samples of approximately 20 fish; monthly commercial landings at local ports.

1939b. Cooperative southern skipjack fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1937):7-9. [J,P]
Results (not very detailed) of 10 days' exploratory skipjack live-bait fishing in the Sulu Sea by a subsidized commercial vessel; chart of locations fished.

1939c. Investigation of the migration of important fishes. Kagoshima-ken suisan shikenjō jigyō hōkoku (1937):69. [J,P]
Relase records of 36 skipjack tagged in Ryukyu waters.

1940a. Experimental skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1938):1-3. [J,P]
Results of 9 exploratory skipjack live-bait fishing cruises in Ryukyu waters from March to July; brief discussion of water temperature and fishing conditions; plot of locations fished; monthly commercial landings at local ports; average lengths and weights of 13 samples of 20 fish each.

1940b. Cooperative southern skipjack fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1938):7-9. [J,P]
Results of 4 exploratory skipjack live-bait fishing cruises to the Sulu Sea from October to February by a subsidized commercial vessel.

1940c. Investigation of the migration of important fishes. Kagoshima-ken suisan shikenjō jigyō hōkoku (1938):43. [J,P]
Release records for 20 skipjack tagged in Ryukyu waters.

KAGOSHIMA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

1941a. Investigation of skipjack fishing. Kagoshima-ken suisan shikenjō jigyō hōkoku (1939):1-3. [J,P]
Results of 10 exploratory skipjack live-bait cruises in Ryukyu waters from March to July; fishing log and station plot; brief discussion of water temperature and fishing conditions; average lengths and weights of 8 samples of 20 fish each; monthly commercial landings at local ports.

1941b. Cooperative southern skipjack fishing experiment. Kagoshima-ken suisan shikenjō jigyō hōkoku (1939):7. [J,P]
Fishing logs for 3 exploratory skipjack livebait fishing cruises to the Sulu Sea from October to January by a subsidized commercial vessel.

KAKIMOTO, DAIICHI, AKIO KANAZAWA, and KENICHI KASHIWADA.

1953. Biochemical studies on skipjack (*Katsuwonus vagans*). IV. Distribution of amino-acid in pyloric caeca. Bull. Jap. Soc. sci. Fish. 19 (6):729-732. [Je,P]
Chemical analysis.

KAMIMURA, TADAO, and MISAO HONMA.

1953. Biology of the big-eyed tuna, *Parathunnus mebachi* (Kishinouye). I. Length frequency of the big-eyed tuna caught in the North Pacific with special reference to biennial frequency. Contrib. Nankai reg. Fish. Res. Lab. 1, Contrib. 46:18 p. [Je,P]
Analysis of size composition of bigeye landed by longlines from 130°E. to 165°W. north of 26°N. from 1948 through 1953; compared for areas and years; discussion of reproduction, growth, and migration.

KANAGAWA PREFECTURE FISHERIES EXPERIMENT STATION.

1951a. Report of South Sea tuna fishing experiments, 1951. 49 p. [J,P]
Detailed results of a longlining cruise to 0°-6°N., 154°-162°E. in January-March: distribution, longline catch rates, relative depth of capture, length frequencies, sex ratios, stomach contents for yellowfin and bigeye tuna. Subsurface water temperatures, salinities; notes on plankton.

1951b. Report of work of the Kanagawa Prefecture Fisheries Experiment Station, 1950:1-107. [J,P]
Results of 5 longlining cruises between 5°-38°N. and 150°-175°E. Yellowfin, bigeye, and albacore catch rates, length frequencies, sex ratios, stomach contents (nonquantitative); relative depth of capture; subsurface water temperatures and sali-

KANAGAWA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

nities, notes on plankton; fishing logs, *N. macropterus* and *P. mebachi* recorded from stomach contents; shipboard refrigeration experiments.

1952a. Report of experimental tuna fishing on the eastern grounds by the Sagami Maru. Maguro gyogyō shiken hōkoku 4:21 p. [J.P]

Report of an exploratory longlining cruise in Feb.-Mar. around 32°N., 171°E. Catch rates of albacore and bigeye; average sizes; length frequency distribution of albacore; estimated depth of capture; sex ratios; water temperatures and salinities to 300 m.; fishing correlated with oceanographic conditions. Complete fishing logs.

1952b. Report of experimental tuna fishing on the eastern grounds by the Sagami Maru. Maguro gyogyō shiken hōkoku 5:26 p. [J,P]

Report of an exploratory longlining cruise in Feb.-Apr. around 30°N., 175°E. Albacore and bigeye catch rates, sex ratios, length frequency distribution; water temperature and salinities to 300 m., correlated with fishing conditions; catch by branch line number. Complete fishing logs.

KANAI, MOTO, and NOBORU KASU.

1938. Report of an investigation of the economics of the Okinawan tuna longline and deep-sea handline fisheries. Okinawa-ken suisan shikenjō hōkoku 1:1-42. [J,P]

History of the fishery, charts of grounds showing expansion, fishing seasons; description and figures of gear and vessels; list of vessels, catch statistics; economics of the fishery: costs of gear, provisions, bait, fuel.

KANAMURA, MASAMI, and KAKUJI IMAIZUMI.

1936a. Report of experimental tuna longlining east of Formosa. In Report of experimental fishing by the Shonan Maru in 1935. Taiwan sōtokufu suisan shikenjō shuppan 3:165-202. [J,P]

Results of fishing at 21°-23°N., 121°-126° E. in Nov.-Dec. Gear dimensions, station plot, fishing log, weather, surface and subsurface temperature and salinity, transparency, water color; yellowfin, bigeye: catch rates, depth of capture; body temperature, sex, maturity, length, weight of 25 yellowfin and 3 bigeye; shark damage rate; tuna catch and water temperature correlated.

1936b. Fishing conditions for tuna longline boats based at Takao. Taiwan sōtokufu suisan shikenjō shuppan 3: 203-207. [J,P]

Operational data (average cruises per season, Oct.-May, average fishing effort, average catch per cruise by species) for 7 commercial boats fishing the Celebes, Sulu, and S. China Seas; plots by 1° squares of catch rates for yellowfin and bigeye.

KANAMURA, MASAMI, and HARUO YAZAKI.

1940a. Investigation of tuna longline fishing grounds in the East Philippine Sea. In Report of fishing ground investigations by the Shonan Maru in 1937. Taiwan sōtokufu suisan shikenjō shuppan 21:1-65. [J,P]

Results of exploratory longlining at 3°-20°N., 123°-131°E. in June-Sept. Fishing log, track chart and station plot; setting, hauling, and soaking time; construction of gear. Subsurface temperatures and salinities, transparency, water color at stations. Yellowfin, bigeye, skipjack, albacore catch rates; depth of capture; catch rates plotted against latitude; stomach contents (non-quantitative); sex and maturity; body temperature (compared with water temperature); length, weight, length-weight relation, age according to Aikawa's tables, condition factor; correlation of yellowfin catch with water temperature, salinity, currents, and weather examined; shark damage rates.

1940b. Investigation of tuna longline fishing grounds in the South China Sea. In Report of fishing ground investigations by the Shōnan Maru in 1937. Taiwan sōtokufu suisan shikenjō shuppan 21:67-117. [J,P]

Results of exploratory longlining at 16°-22°N., 116°-121°E. in Feb.-May. Fishing log with operational data, track chart and station plot; gear construction. Subsurface temperatures and salinity, transparency, water color at stations. Yellowfin, albacore: catch rates; depth of capture; stomach contents (non-quantitative); body temperature, compared with water temperature; length, weight, age according to Aikawa's tables, condition factor, sex and maturity; correlation of dark or "green" flesh color with kind of feed, condition factor, and sexual maturity attempted.

KASHIWADA, KENICHI, DAIICHI KAKIMOTO, and YOSHISHIGE HORIGUCHI.

1952. Biochemical studies on skipjack *(Katsuwonus vagans)*. I. Chemical components of pyloric caeca and extractive matter. Bull. Jap. Soc. sci. Fish. 18(4):147-150. [Je,P]

Fat, moisture, ash, protein content; changes in nitrogen compounds by autolysis.

WADA, KENICHI, DAIICHI KAKIMOTO, ad TOSHIMORI YAMASAKI.
953. Biochemical studies on skipjack. III. On the nitrogen compounds in skipjack pyloric caeca extract. Bull. Jap. Soc. sci. Fish 19(1): 15-18. [J,P]
Chemical analysis.

GENJI.
940. An account of longline fishing for tuna. Nanyō suisan jōhō 4(7): 8-10. [J,P]
General account of a longlining trip in Palau waters: brief notes on yellowfin sex ratio and maturity, on soaking time and bait loss, and on working efficiency of the fishermen.

AMURA, HYŌZŌ.
939. Observations on oceanography and fishing conditions in Palau waters. Nanyō suisan jōhō 3(1):2-6. [J,P]
General discussion of yellowfin and skipjack fishing in relation to ocean currents in the Palau area.

ANA, TAKESHI.
934. On the relation between the tuna fishery and oceanographic conditions. Hokkaidō suisan shikenjō suisan chōsa hōkoku 31:80 p. (Spec. sci. Rep.: Fish. U. S. Fish. Wildl. 78). [P]
Thunnus orientalis, northern Japan: catch statistics; fishing conditions related to temperature, currents, abundance of other fishes, sunspots, lunar period, wind direction; monthly average size of fish in commercial landings; tag recovery records for 6 fish.

935. The tuna spawns in the Japan Sea. Suisan kenkyū shi 30:284-286.
Black tuna: spawning.

937. The catch of tunny, *Thunnus orientalis* T. and S., off Kushiro, Hokkaido, in relation to the vertical difference in water temperature. Bull. Jap. Soc. sci. Fish. 6(2):73-74. (Pacific Oceanic Fishery Investigations Translation No. 50. In: Spec. sci. Rep.: U. S. Fish Wildl. 52. [P]
Temperature difference between surface and 50 m., and average numbers of large, medium, and small fish taken per trip in 13 years; Pacific Ocean-northwest.

1938. On tuna fishing conditions at Urakawa. Hoku sui shi sui chō hō 43:125-134. [J]
Thunnus orientalis:fishing conditions, Pacific Ocean - northwest.

ASAKI, TSUYOSHI.
1952. On the populations of the skipjack, *Katsuwonus pelamis* (Linnaeus), migrating to the Northeastern Sea Area along the Pacific coast of Japan. Bull. Tōhoku reg. Fish. Res. Lab. 1:1-14. [Je,P]
Populations distinguished by size composition, condition factor, and biting qualties; distribution correlated with oceanographic conditions; length-weight relation; age determination (according to Aikawa's tables); Pacific Ocean-northwest.

KIDA, TAKEO.
1936. On the surface temperature of water in the tunny fishing grounds off Kushiro and Urakawa in summer. Bull. Jap. Soc. sci. Fish. 5(2):87-90. [Je,P]
Thynnus thynnus: fishing condition correlated with water temperature; size composition of schools; relation to other fishes, birds, plankton; Pacific Ocean-northwest.

KIKAWA, SHŌJI.
1953. Observations on the spawning of the big-eyed tuna (*Parathunnus mebachi* Kishinouye) near the southern Marshall Islands. Contrib. Nankai reg. Fish. Res. Lab. 1, Contrib. 24:10 p. [Je,P]
Mature and ripe fish abundant in longline catch in southern Marshalls, June-August; occurrence of ripe fish in relation to area, oceanographic conditions, month, and size composition; ripe eggs described and figured; successful artificial fertilization described and embryo figured.

KIMURA, KINOSUKE.
1932. Growth curves of blue-fin tuna and yellow-fin tuna based on catches near Sigedera, on the west coast of Prov. Izu. Bull. Jap. Soc. sci. Fish. 1(1):1-4. (Pacific Oceanic Fishery Investigations Translation No. 37. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 22). [P]
Neothunnus macropterus, Thunnus orientalis: growth rates determined from size groups; Pacific Ocean-northwest.

1933. Statistical analysis of the catch of young bluefin tuna and yellowtail in Suruga Bay. Bull. Jap. Soc. sci. Fish. 2(4):183-194. [Je,P]
Thunnus orientalis: trap catches correlated with area and with season; Pacific Ocean-northwest.

1935. Statistical analysis of the catch by keddle nets, along the coast of Suruga Bay. Rec. oceanogr. Wks. Jap. 7(1):1-36.
Neothunnus macropterus, Thunnus orientalis: Pacific Ocean-northwest; seasonal distribution of trap catches, 1927-32; weight frequencies; age-growth curves.

1941. Skipjack fishing conditions. Suisan seizō kōgaku kōza 1:36 p. [J]
Northwest Pacific Ocean: distribution, mi-

KIMURA, KINOSUKE.—Continued
gration, catch correlated with water temperature; age and size composition of commercial catches.

1942a. Tuna and spearfish fishing conditions. Suisan seizō kōgaku kōza 5:122 p. [J,P]
Albacore, yellowfin, bigeye tuna; northwest Pacific, Indonesian waters; landings from various longlining grounds (1936-40), fishing seasons, catch per day fished, relation of water temperature to fishing conditions; age (from Aikawa's tables) and rough size composition of albacore and yellowfin catches.

1942b. High seas fisheries. Kaiyō no kagaku 2(3): 142-7. [J,P]
Albacore, black tuna, skipjack, bigeye, yellowfin; popular account of livebait fishing and longlining grounds and seasons, relation to water temperature; proportion of skipjack landings from various areas, 1937-39.

1949. Atlas of skipjack fishing grounds—with data on the albacore grounds. Tokyo. Kuroshio Publ. Co., 44 p. [J,P]
Japan: catches of albacore and skipjack in relation to surface water temperature; chart of fishing situation and isotherms for each 10-day period of the year.

KIMURA, KINOSUKE, and KAZUMI ISHII.
1931. Fishing conditions in the northeastern part of Suruga Bay (Part 1). Tunas and spearfishes and their young. Suisan butsuri danwakai kaihō 33:526-538. [J]
Pacific Ocean - northwest: tuna, young.

1932. Fishing conditions in the northeastern part of Suruga Bay (Part 2), with the growth rates of black tuna and yellowfin based on catches from the Shigedera fishing grounds. Suisan butsuri danwakai kaihō 38:562-580. [J]
Thunnus orientalis and *Neothunnus macropterus*: growth, fishing conditions; Pacific Ocean-northwest.

1933a. Statistical analysis of the catch at the northeastern end of Suruga Bay. I. Bluefin tuna (*Thunnus orientalis* T. and S.). Bull. Jap. Soc. sci. Fish. 1(5):221-229. [Je,P]
Size composition, fishing conditions correlated with season; Pacific Ocean-northwest; annual and seasonal variations in catch and sizes of fish in Japanese tuna traps.

1933b. Statistical analysis of the catch at the northeastern end of Suruga Bay. II. Yellowfin tuna, swordfish, yellowtail, etc. Bull. Jap. Soc. sci. Fish. 2(2):69-79. [Je,P]

KIMURA, KINOSUKE, and KAZUMI ISHII.—Continued
Seasonal distribution of trap catches; correlation with water temperature; Pacific Ocean-northwest.

KIMURA, KINOSUKE, MITSUO IWASHITA, and TOSHIRŌ HATTORI.
1952. Image of skipjack and tuna recorded on echo sounding machine. Bull. Tōhoku reg. Fish. Res. Lab. 1:15-19. [Je,P]
Depth recorder traces of skipjack, albacore, and bigeye schools; notes on vertical distribution and schooling habits.

KODAMA, MASAHARU, K. IIZUKA, and T. HARADA.
1934. Weight ratio of various body parts and analyses of the normal constituents of fresh flesh of important South Sea fish. Taiwan sōtokufu suisan shikenjō jigyō hōkoku (1932), Technol. Sect. 1-6. [J,P]
Skipjack and tuna examined.

KOYASU, SHŌZŌ.
1931. On the skipjack fishing conditions off eastern Honshū. Suisankai 579:2-25; 580-24-30. [J]
Katsuwonus pelamis: fishing conditions, Pacific Ocean-northwest.

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1951a. Ein elektrisches Thunfischangelgerät. Arch. Fischereiwiss. 3(1/2).
Fishing methods and gear; North Sea.

1951b. Thune werden elektrisch geangelt. Fischereiwelt 3(10):160-1. [P]
Description and figure of electrified hook, line, and accessories for stunning tuna.

KUMAMOTO PREFECTURE FISHERIES EXPERIMENT STATION.
1946. Experimental pole and line fishing for skipjack. Kumamoto-ken suisan shikenjō jigyō hōkoku (1942, 1943, 1944):3-5. [J,P]
Summary results of 4 cruises off southern Japan in July-Nov. Surface water temperatures discussed.

KUMATA, TŌSHIRO, ET AL.
1941. Illustrated atlas of edible marine animals and plants of the South Seas. Nissan Fish. Res. Sta., p. 62, 65. [J]
Katsuwonus vagans, Neothunnus macropterus, Parathunnus mebachi: distribution; English and Japanese common names, figures, Dutch and Malay common names of *N. macropterus*, and *P. mebachi*.

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Stomach contents of *Germo germo* noted.

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949. Report of investigations of skipjack and tuna resources in 1947 by the Nakamura research staff. Cent. Fish. Exp. Sta. Rep. 1:7 p. (Pacific Oceanic Fishery Investigations Translation No. 33. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 17). [P]
Katsuwonus pelamis, central and south Japan; morphometric data, meristic counts; size composition and sex ratio of commercial catch; sexual maturity, gonad weights, egg counts; stomach contents; catch statistics; fishing grounds and seasons.

ANOIS, E.
933. Les transgressions océaniques. Bull. Inst. océanogr. Monaco 613:1-16.
Germo alalunga, Thunnus thynnus: occurrence in relation to water temperature and salinity; Atlantic Ocean.

938. L'influence des transgressions sur la biologie et la pêche. In: L'Atlantique (Histoire et Vie d'un Océan), p. 246-286. Paris, Albin Michel.
Germo alalunga: races, migrations.

951. Sur la présence du thon blanc ou germon sur les côtes du Venezuela et sur le lieu de ponte de cette espèce dans l'Atlantique Nord. C. R. Acad. Sci. Paris 232:1029-1030.
Thunnus (*Germo*) *alalunga;* Atlantic Ocean, Caribbean Sea: spawning, migration; Sargasso Sea as probable spawning ground.

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34a. *Auxis thazard.* In: Faune Ichthyologique de l'Atlantique Nord, No. 15. [P]
Plate including description, synonymy, distribution.

34b. *Euthynnus alletteratus.* In: Faune Ichthyologique de l'Atlantique Nord, No. 15. [P]
Plate including description, distribution, synonymy.

34c. *Germo alalunga.* In: Faune Ichthyologique de l'Atlantique Nord, No. 15. [P]
Plate including description, distribution, synonymy.

934d. *Katsuwonus pelamis.* In: Faune Ichthyologique de l'Atlantique Nord, No. 15. [P]
Plate including description, distribution, synonymy.

949. Germon. Résumé des connaissances acquises sur la biologie du germon. Rev. Trav. Off. Pêches marit. 15:1-42. [P]
Germo alalunga: synonymy, common and scientific names; systematics, figure, measurement data; digestive, respiratory, and circulatory apparatus; reproduction, distribution (geographical and vertical), food, parasites, age and growth, migration, larvae; bibliography.

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Attempt to standardize techniques in taking morphometric measurements.

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1932. La nourriture du germon (*Germo alalunga* Bonnaterre). Arch. Zool. exp. gén. 74:531-540. [P]
Stomach contents of *Germo alalunga.*

1933. Présence d'*Anotopterus pharao* Zugmayer dans l'estomac des germons. C. R. Acad. Sci., Paris 197:1261-1752.
Germo alalunga, Atlantic Ocean: food.

1934. La faune pélagique de l'Atlantique au large du Golfe de Gascogne recueillie dans des estomacs de germons. Première Partie: Poissons. Ann. Inst. Océanogr. 14:249-418.
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P.atlanticus: distribution; Atlantic Ocean.

1940. La faune pélagique de l'Atlantique au large du Golfe de Gascogne recueillie dans des estomacs de germons. Troisième Partie: Invertébrés (Céphalopodes exclus.). Parasites du germon. Ann. Inst. Océeaogr. 20:127-310.
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LETACONNOUX, R.
1950. Le germon (*Germo alalunga* Gmelin). Examen du nombre de branchiospines. Ann. biol., Copenhague 7:63. [P]
Meristic counts.

LOZANO, FERNANDO.
1950. Notas sobre el bonito del norte o albacora (*Germo alalunga* Gmelin) de Galicia. Bol. Inst. esp. Oceanogr. 36:1-13. [P]
Morphometrics, notes on sexual maturity, food, age, fishing season and catch, relation of albacore and sardine fisheries.

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LÜLING, KARL H.—Continued

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942b. On the gonads of skipjack from the adjacent waters of Palau. Kagaku nanyō 5(1): 117-122. (Pacific Oceanic Fishery Investigations Translation No. 19. In: Spec. sci. Rep.: Fish. U. S. Fish Wildl. 20). [P]
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Fishing logs; skipjack, bigeye, albacore catches recorded with surface water temperature and specific gravity, Japanese waters.

1930b. Skipjack fishing and oceanographic conditions. Mie-ken suisan shikenjō hōkoku (1927): 15-17. [J,P]
Skipjack fishing conditions discussed in relation to water temperature and specific gravity; Japanese waters, May-August; plots of two 100-mile oceanographic sections.

1930c. Investigation of tuna fishing grounds and guidance in fishing. Mie-ken suisan shikenjō jigyō hōkoku (1927):18-33. [J,P]
Longline fishing logs and station plots, Japanese waters; albacore, bigeye, black tuna, yellowfin catches recorded with surface water temperature and specific gravity; plots of two 100-mile oceanographic sections; fishing discussed in relation to oceanographic conditions.

1930d. Investigation of skipjack fishing grounds and guidance in fishing. Mie-ken suisan shikenjō jigyō hōkoku (1928):1-18. [J,P]
Livebait fishing logs and station plots, Japanese waters; skipjack, albacore, bigeye, yellowfin catches recorded with surface water temperature and specific gravity; plots of two 100-mile oceanographic sections; fishing discussed in relation to oceanographic conditions.

1930e. Investigation of tuna fishing grounds and guidance in fishing. Mie-ken suisan shikenjō jigyō hōkoku (1928):19-33. [J,P]
Longline fishing logs and station plots, Japanese waters; albacore, bigeye, black tuna, yellowfin catches recorded with surface water temperature and specific gravity; plots of two 100-mile oceanographic

MIE PREFECTURE FISHERIES EXPERIMENT STATION.—Continued
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Fishing conditions; Pacific Ocean - northwest.

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Fishing conditions; Pacific Ocean—northwest.

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1951. Studies on green meat in albacore. In: Itsumi shō tōsen rombun: 1-81. Publ. by Shizuoka kanzume kyōkai gijutsubu. [J,P]
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1951a. Estimation of age and growth of yellowfin tuna (*Neothunnus macropterus* Temminck and Schlegel) in Hawaiian waters. (Unpublished thesis submitted for the degree of Master of Science, University of Hawaii, Honolulu). [P]
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1953b. Un caractère systématique pouvant servir à séparer les espèces de Thunnidae atlantiques. Rev. Trav. Inst. sci. tech. Pêches marit. 18 (1):65-74. [P]

Descriptions and figures of livers of *T. thynnus, G. alalonga, P. obesus, Neothunnus albacora,* and *S. sarda;* liver morphology as a systematic character.

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MURPHY, GARTH I., and RICHARD S. SHOMURA.

1952. New tuna source: Fish and Wildlife Service's investigation reveals potential new grounds. Pan-Amer. Fish. 6(10):14-16. [P]

Results of experimental longlining in equatorial waters between 150° and 165° W. Yellowfin, bigeye, albacore, skipjack catches, total catch rates, geographical distribution; relation of upwelling to tuna abundance; possibility of commercial exploitation.

1953a. Longline fishing for deep-swimming tunas in the central Pacific, 1950-51. Spec. sci. Rep: Fish. U. S. Fish Wildl. 98:47 p. [P]

Description of longline fishing; horizontal and vertical distribution of deep-swimming tunas in equatorial waters; sex ratios and size composition of yellowfin, bigeye, albacore, skipjack; relation of upwelling to zooplankton and tuna abundance; commercial possibilities.

1953b. Longline fishing for deep-swimming tunas in the central Pacific, January-June 1951. Spec. sci. Rep: Fish. U. S. Fish. Wildl. 108:32 p. [P]

Results of experimental longlining in equatorial waters from 120°W. to 180°. Vertical and horizontal distribution of yellowfin, bigeye, albacore, skipjack; size compositions and sex ratios. Operational data and comparison of gear with shallow and deep float lines. Effect of wind on upwelling and tuna abundance.

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Example of hermaphroditism recorded and described.

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Description and figure of mature egg; gonads figured, distribution, sexual maturity, spawning areas and seasons.

1939a. Summary of an investigation of scombroids of Formosan waters. Taiwan suisan zasshi 288:22-26. [J,P]

N. macropterus, T. orientalis, P. mebachi, T. germo, K. pelamis, Euthynnus yaito, Kishinoella rara, Gymnosarda nuda, Auxis hira, A. maru: listed as occurring in Formosan waters; Japanese common names.

1939b. Report on the investigation of Thunnidae in Formosan waters. Taiwan sōtokufu suisan shikenjō shuppan 13:1-15. [Je,P]

Auxis hira, A. maru, Euthynnus yaito: classification; Japanese common names; synonymy. *Katsuwonus pelamis, Kishinoella rara, N. macropterus, Parathunnus mebachi, Thunnus germo, T. orientalis:* classification; description; distribution; synonymy; Japanese common names; figures of all except *N. macropterus, P. mebachi,* and *T. germo. N. macropterus*: spawning, morphometric data; compared externally with *N. itosibi* and *Semathunnus guildi. K. rara* compared externally with *K. zacalles;* spawning of *T. orientalis.*

1939c. Notes on differences between *Neothunnus macropterus* and *Neothunnus itosibi.* Taiwan suisan zasshi 288:27-32. [J,P]

N. *macropterus*: classification, morphometric data, synonymy; *Neothunnus* compared with *Semathunnus.*

1941. On the body temperatures of some species of Thunnidae and Istiophoridae. Suisan gakkwai hō 8(3):256-263. [J,P]

Yellowfin tuna, bigeye tuna, Formosan and Philippine waters; body temperatures compared with water temperatures at presumed depth of capture.

NAKAMURA, HIROSHI.—Continued

1943. Tunas and spearfishes. Kaiyō no kagaku 3 (10):445-459. (Pacific Oceanic Fishery Investigations Translation No. 47). [P]

Neothunnus macropterus, N. rarus, Parathunnus mebachi, Thunnus germo, T. orientalis: classification, distribution, food, Japanese common names, spawning.

1949. The tunas and their fisheries. Tokyo, Takeuchi Shobō. 118 p. (Translated as Spec. sci. Rep: Fish. U. S. Fish Wildl. 82.) [P]

Thunnus orientalis, Germo germo, Parathunnus mebachi, Neothunnus macropterus, N. rarus: anatomy, description, figures, classification, keys; general account of food, spawning, growth, migration, distribution of longline catch rates in western Pacific; fisheries, relation of fishing grounds to topography and oceanography, fishing seasons; bibliography. Similar material on spearfishes.

1951. Tuna longline fishery and fishing grounds. Tokyo, Takashima Shoten pub. 144 p. (Also published as Nankai Regional Fisheries Research Laboratory Rept. No. 1. Translated as Spec. sci. Rep: Fish. U. S. Wildl. 112) [P]

Compilation of research vessel longline catch rates for approximately 20 prewar years. Geographical and seasonal distribution of *N. macropterus, P. sibi, G. germo, T. orientalis,* and spearfishes in the western Pacific and Indonesian waters; average catch rates for each species plotted by 1° squares. Relation of fishing grounds and seasons to meteorological and oceanographical phenomena.

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1953. Size composition of the albacore and bigeyed tuna caught in the North Pacific area. Contrib. Nankai reg. Fish. Res. Lab. 1, Contrib. 12:6 p. [Je,P]

Length composition of longline-caught albacore and bigeye from the central North Pacific; discussion of age and growth, and of annual variations in size composition.

NAKAYAMA, TAKUZŌ.

1948. Calculation of the cost price in the tuna fishery. Suisankai 770:10-16. (In: Spec. sci. Rep: Fish: U. S. Fish Wildl. 79). [P]

Japanese tuna longline fishery; economic statistics.

NANKAI REGIONAL FISHERIES RESEARCH LABORATORY.

1951a. Report No. 1. 144 p. [J,P]

See Nakamura, Hiroshi, 1951. Contents are identical, but this Report has the text and the charts bound separately.

NANKAI REGIONAL FISHERIES RESEARCH LABORATORY.—Continued

1951b. Supplementary report no. 1:194 p. [J,P]
Distribution of albacore longline catch rates in the northwest Pacific by 1° squares, 1948-51; albacore length frequencies by month and area; survey of construction and dimensions of longline gear of numerous vessels, with area of employment and catch rates by species.

NAVARRO, FRANCISCO DE P., and F. LOZANO.

1950. Carta de pesca de la costa del Sahara, desde el Cabo Juby al Cabo Barbas. Trab. Inst. esp. Oceanogr. 21:24 p. [P]
Atún (*Thunnus thynnus* L.), patudo (*Parathunnus obesus* Lowe), rabil (*Neothunnus albacora* Lowe), bonito de altura (*Katsuwonus pelamys* L.), bonito del norte (*Germo alalunga* Gmelin), melva (*Auxis thazard* Lacep.): occurrence and fishing methods.

NAVAZ, JOSÉ M.

1950. Contribución al estudio de los escómbridos de la costa vasca (atún, bonitos, y melva). Bol. Inst. esp. Oceanogr. 31:21 p. [P]
Morphometrics, fishing seasons, catch of *Thunnus thynnus, Germo alalunga, Katsuwonus pelamis,* and *Auxis thazard* in the Bay of Biscay; bibliography; Spanish and Basque names.

NICHOLS, JOHN T., and F. R. LA MONTE.

1941. Yellowfin, Allison's, and related tunas. Ichth. Contr. Int. Game Fish Assn. 1(3):27-32 [P]
Neothunnus albacora, N. allisoni, N. catalinae, N. rarus: classification, description, English common names, key, synonymy. Provisional subspecies: *Neothunnus albacora macropterus, N. allisoni allisoni, N. allisoni itosibi,* and *N. rarus zacalles,* proposed.

NIGRELLI, ROSS F., and H. W. STUNKARD.

1947. Studies on the genus *Hirudinella,* giant trematodes of scombriform fishes. Zoologica, N. Y., 31(4):185-196. (Contribution No. 747, Dept. of Tropical Research, N. Y. Zoological Society).
Table 4: *Hirudinella* from scombriform fishes other than *Acanthocybium*: *Parathunnus atlanticus, Katsuwonus pelamis, Euthynnus alletteratus, Neothunnus macropterus, Thunnus thynnus.* Lists name of collector, host, locality and figure.

NISHIKAWA, SADAICHI.

1934. On the future of the high-seas skipjack and tuna fisheries and standards for their operating methods. Rakusui 29(4):20-22. [J]
Fishing methods and gear.

NISKA, EDWIN L.

1953. Construction details of tuna long-line gear used by Pacific Oceanic Fishery Investigations. Comm. Fish. Rev. U. S. Fish Wildl. 15(6):1-6. Also Separate No. 351. [P]
Description of gear construction.

NIWA, HITOMARO.

1937. On the pigments in the muscles of fishes. Rep. No. 1, Pigments of tuna muscle. Suisan kenkyū shi 32(6):306-313. [J]
Chemical analysis.

NOGUCHI, SADAMI.

1938. The Ogasawara Is., and the future of our tuna fishery. Suisankai 666:44-46. [J]
Pacific Ocean - northwest.

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1952-3. Survey of the high-seas tuna fisheries based on landings at Misaki, Tokyo, and Yaizu. Reports of the following months' operations are in the indicated numbers of the Kanagawa suishi geppō: April and May 1952, 1:3-20; June 1952, 2:1-7; July 1952, 3:1-6; Aug. 1952, 4:1-10; Sept. 1952, 5:1-8; Oct. and Nov. 1952, 6:1-10; Dec. 1952 and Jan. 1953, 7:1-15; April 1953, 9:1-10; June 1953, 11:1-20; July 1953, 12:1-18; the reports of February and March 1953 operations were published as Maguro-rui mizuagechi chōsa (unnumbered, undated) by the Kanagawa Prefecture Fishesies Experiment Station; the report for May 1953 operations is in Report of survey for tuna fishing 1:1-22; the report for August 1953 operations is in Tuna fishing 4:17-32. [J,P]
Average catch rates for yellowfin, bigeye, albacore, bluefin, skipjack, and spearfishes reported by Japanese longline vessels from various areas of the western and central Pacific, Indonesian waters, and the Indian Ocean by months; plots of locations fished by the vessels investigated; discussion of fishing conditions in each area for the month; length frequencies of each species by area.

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1930. Report of experimental tuna fishing in the Kantō region (1927). Ōita-ken suisan shikenjō jigyō hōkoku (1927-28):1-40. [J,P]
Longline catches of yellowfin, bigeye, and black tuna off central Japan: morphometric data, body temperatures compared with water temperatures; gear construction, general account of tuna fisheries and bases of the region.

OKADA, YAICHIRŌ, and KIYOMATSU MATSUBARA.

1938. Keys to fishes and fish-like animals of Japan. Tokyo, Sanseidō Co., Ltd., p. 146-150. [J]
Auxis hira, A. tapeinosoma, Euthynnus alletteratus, E. yaito, Germo germo, Kat-

OKADA, YAICHIRŌ, and KIYOMATSU MATSUBARA.—Continued

suwonus vagans, Kishinoella rara, Neothunnus itosibi, N. macropterus, Parathunnus orientalis: classification, description, key, Japanese common names.

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OKINAWA PREFECTURE FISHERIES EXPERIMENT STATION.—Continued

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Southern bluefin (*T. maccoyii*), albacore (*T. germo*), yellowfin (*Neothunnus macropterus*), striped tuna (*Katsuwonus pelamis*), bonito (*Sarda australis*): recorded; description of *N. macropterus.*

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Distribution, feeding habits, stomach contents, spawning.

1942b. The tuna *Kishinoella tonggol* Bleeker in Australia. J. Coun. sci. ind. Res. Aust. 15(2): 101-112.

Distribution, description, ratios of various body proportions, internal anatomy, synonymy; compared with *K. zacalles, Neothunnus rarus, Thunnus nicolsoni, Thynnus tonggol;* figures of *T. tonggol* and *K. tonggol,* cranium of *K. tonggol* figured.

1947. A report on commercial tuna trolling tests in southeastern Australia. J. Coun. sci. ind. Res. Aust. 20(1):1-16.

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SHAPIRO, SIDNEY.—Continued
T. orientalis: bibliography, distribution, Ryukyuan common names, migration, spawning of *K. pelamis*.

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California cannery receipts and pack of tuna, mackerel and anchovies; U. S. imports into Arizona and California, and other information.

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